Alberta Saskatchewan Manitoba Agriculture

GUIDE TO COMMERCIAL STRAWBERRY PRODUCTION

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Foreword

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Introduction

Statistics

There are approximately 526 ha (1300 acres) of strawberries in production on the Prairies. This small, developing industry has an annual gross income of 6.1 million dollars.

Most strawberries grown on the Prairies are marketed on a U-Pick basis. However, in areas of market saturation, direct sales to hotels, restaurants, institutions, roadside stands and processing outlets are on the increase. Manitoba's U-Pick industry is levelling off and is diversifying into other fruit crops and markets. In Saskatchewan and Alberta, the U-Pick industry is just being established and is expected to grow significantly over the next five years. Based on per capita consumption of 2.4 kg (5.3 lb.), the total prairie strawberry industry has a potential to expand to 1926 ha (4700 acres) within the next decade.

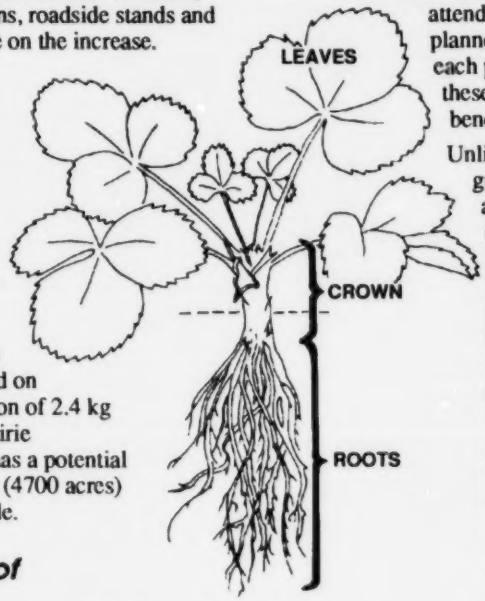


Fig. 1 The strawberry plant
(Source: Malcom N. Dana, Fig. 1-7.)

The Purpose of This Guide

This guide outlines the general practices and fundamentals for commercial strawberry production on the Prairies. However, growers should adapt this information to their own farms. For example, the frequency of insecticide applications may have to be increased during an early, hot, dry spring when insect populations build up rapidly. Similarly, fungicide sprays may be required more frequently during cool, wet summers. Monitoring for pests to minimize spray applications and costs is essential to today's strawberry grower. For optimum yields and berry quality, pesticide applications must be well timed and accurate.

To be fully informed on local conditions and new developments, growers should attend the field days and seminars planned by grower associations in each province. Membership in these associations provides many benefits to growers.

Unlike extensive crops such as grains or oilseeds, strawberries are an intensely-managed crop requiring precise timing. Yields and quality achieved during the short three week picking season hinge on timely management practices of the previous year, as well as care and maintenance before picking.

Growers entering the industry need these basic requirements:

1. Suitable land
2. Access to an adequate quantity and quality of water for irrigation
3. Financial resources that permit a significant level of investment plus input costs
4. The ability to apply intensive management skills to the crop in a precisely timed manner
5. The ability to determine market potential
6. The willingness to accept risk

New growers should proceed on a small-but-graduated scale. Increases in the size of the production unit should be accompanied by increased knowledge gained from experience and study, including a continuing evaluation of the market potential.

TABLE 1
Strawberry Production on the Prairies

	Area in 1989		Projection for 1994	
	ha	acres	ha	acres
Alberta	121	300	243	600
Manitoba	324	800	384	950
Saskatchewan	101	250	283	400
Total Prairies	**546**	**1350**	**910**	**1950**

The Strawberry Plant

An understanding of strawberry plant biology will help growers adapt and modify the general recipe of strawberry production to meet their specific conditions. This guide will discuss two major types of strawberries: June bearers and day neutrals.

The major parts of the plant are the roots, crown, leaves and flowers (Figure 1). These parts will be described here and will be referred to in sections outlining cultural practices.

The Root

The root system consists of main or primary roots and secondary roots which grow from the primary roots (Figure 2). A mature plant may have between 25 and 35 primary roots. They may live one or more years with new primary roots being produced at a higher point on the base of the crown.

The strawberry plant is shallow rooted. Most of its roots are contained in the top 15 cm (6 in.) of soil.

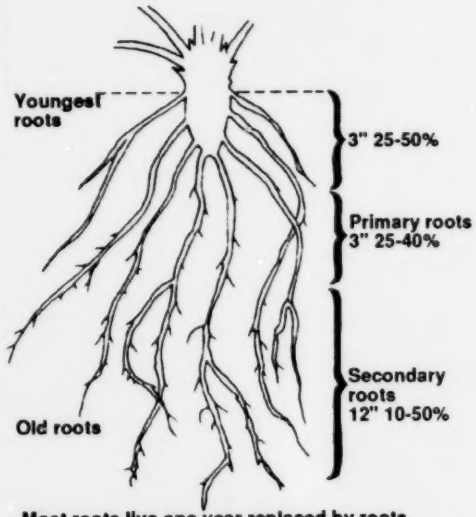

Youngest roots
3" 25-50%
Primary roots 3" 25-40%
Secondary roots 12" 10-50%
Old roots
Most roots live one year replaced by roots higher on crown

Fig. 2 Typical root system of a mature plant may have from 25-35 roots plus hundreds of secondary one.

Day neutral plants have a shallower root system with most roots in the top 8 to 10 cm (3 to 4 in.).

The Crown

The crown is a short stem where leaves develop at points called nodes or auxiliary buds (Figure 3). New leaves develop with a bud in the axil of each leaf (auxiliary buds). These auxiliary buds will either remain undeveloped, grow and form runners or grow to form a side or branch crown.

Environmental factors like day length and temperature influence the development of auxiliary buds. The buds of June bearers develop into runners during the summer's long 14 to 16 hour days. Once the days grow shorter in August and September, the buds no longer form runners. Instead they form branch crowns and flower buds. The more branch crowns that are formed, the greater the potential for fruit production during the next year since each crown can produce one flower stalk on which fruit is borne (Figures 4 and 5).

The buds of day neutrals can initiate flowers under any day length. For the Prairies this can range from mid June to October.

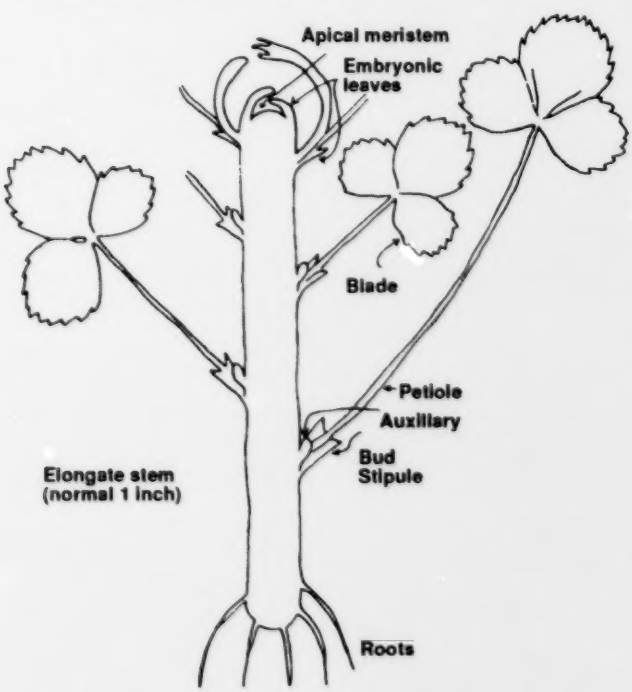


Fig. 3 View of strawberry crown greatly elongated to show parts.

Flower Stalk (Inflorescence)

Flower buds are formed in the tip of the crown in what is known as terminal inflorescence

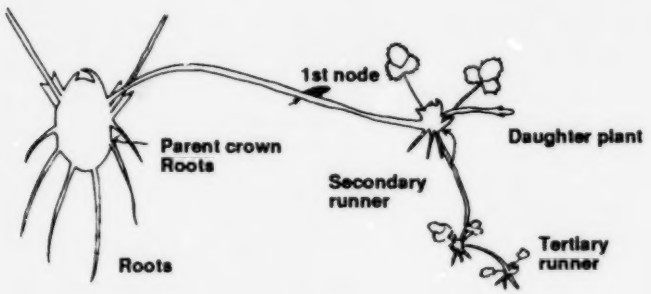


Fig. 4 A strawberry runner (daughter plant).
Typically two nodes in length the daughter plan forms a continuation runner from the lower auxillary bud.

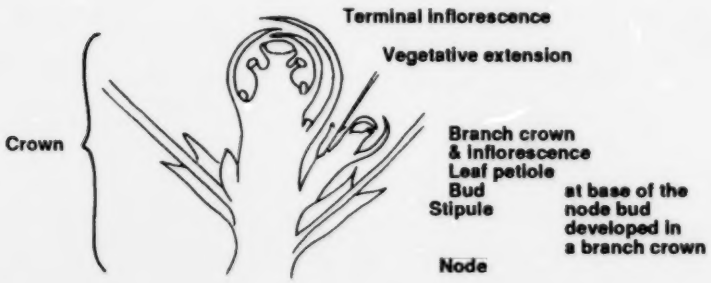


Fig. 5 Apex of strawberry crown

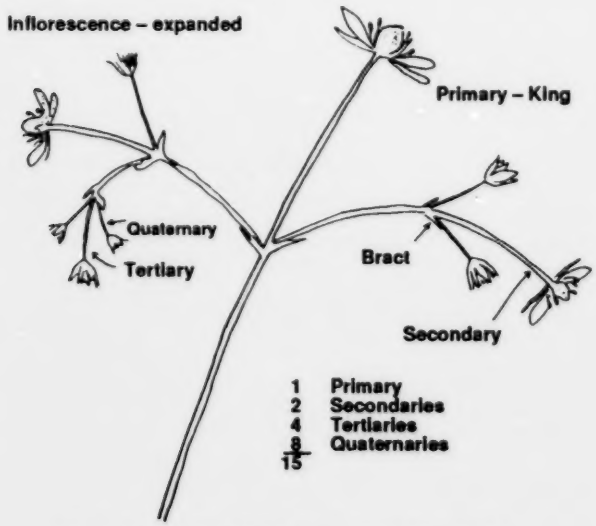


Fig. 6 Typical strawberry inflorescence or flower stalk.

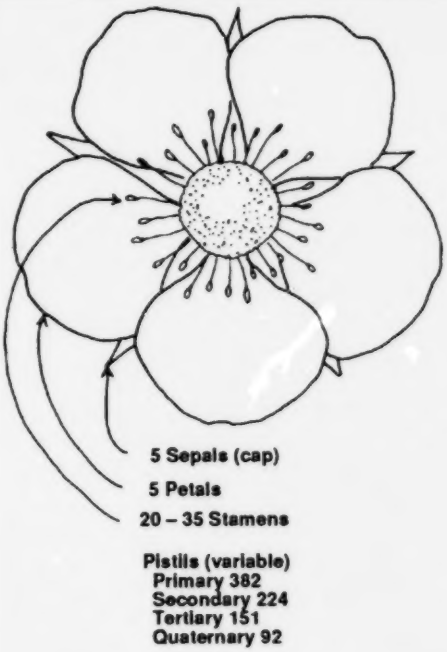


Fig. 7 Strawberry flower.

(Figure 6). Each flower (Figure 7) has five petals and 20 to 35 stamens (male parts) with 100 to 400 pistils (female parts).

The stamens bear pollen grains that must be transferred by bees to the pistil before fertilization and fruit development can take place. Cool or wet weather discourages bees and results in poor or partial fertilization, which in turn leads to misshapen berries or nubbins. Temperatures below freezing will also damage stamens by turning them black in colour. Flowers with blackened stamens will not develop into berries.

The inflorescence develops a central or primary flower that opens first. This is followed by smaller secondary, tertiary and quaternary flowers opening up in sequence. The large primary flower develops into the largest berry, known as the "king" berry.

Daytime temperatures of 25°C (77°F) or more and similar evening temperatures reduce flower initiation in day neutrals.

It usually takes about 30 days for flowers of June bearers to develop into fruit. This period may be reduced to 18 days with good growing conditions and high temperatures. Adverse conditions like cool weather could extend development to 40 days or more.

Site Selection

Site selection can have a significant bearing on the success of a U-Pick operation. Growers should consider factors such as soil, previous crops, water quality, micro climate, shelterbelts and markets.

Soil Type

The best soil for berry production is deep, well drained sandy loam, well supplied with humus (over 2% organic matter). Heavy clay soils that are usually poorly drained, encourage disease development and impede precisely timed field operations. Coarse textured sandy soils are often infertile and droughty, and require more frequent irrigation and greater attention to fertilization practices.

Saline soils are not appropriate since strawberries have a low tolerance to salts. (The sensitive range is 1 mS/cm.) Plants established in low-lying muck or organic soils are more vulnerable to frost injury.

Surface Drainage

The surface drainage system must permit water to move from the field quickly and completely. Water standing on the strawberry field for a day or two will injure plants, especially when they are growing actively.

Fumigation, an option for limited land base.

Soil Tilth

Soil tilth and nutrient availability can be improved by using green manure crops such as field peas, buckwheat, canola or rye. These crops can be rotated with the strawberry crop.

Internal Drainage

Poorly drained sites should be avoided. On sites with certain contours, such as dips, ridges and slopes, poor drainage can cause "yellowing" in strawberries. This condition can significantly reduce yields.

On sites where drainage is a problem, the use of clay or plastic drainage tile could be considered. Your Provincial Water Services Branch provides an advisory service for problems of this kind.

pH

Strawberries prefer slightly acidic soil with pH 5.5 to 6.5. However, good vigor has been obtained on soils with a pH slightly higher than neutral (7.5). Soil pH levels over 8 can adversely affect certain strawberry nutrition, especially the iron levels in certain cultivars. Yellowing in strawberries is also common where soil pH is high.

The use of green manures and acidifying fertilizers can alter the soil pH to some degree.

Salinity and Alkalinity

The salt content (salinity) of some prairie soils is too high for successful commercial strawberry production. Strawberry plants have a low tolerance to salts and are sensitive at 1 mS/cm. For each unit increase in salinity above this threshold, yields decrease by 33%.

Irrigation water with significant salt content, combined with poor soil structure, may also cause soil to develop unacceptable salinity levels.

High alkaline soils can occur in bands or patches throughout a field. In strawberry production, this can cause yellowing or chlorosis of the plants, a condition that can lead to significant yield losses or complete plant set-back.

Previous Crops

Strawberries should not be planted in soils where strawberries, raspberries, alfalfa, potatoes, tomatoes, peppers or eggplants have been grown in any of the previous four years unless the soil has been fumigated.

The fungus diseases, black root rot and verticillium wilt will attack the above crops and build up in the soil. These diseases reduce the productivity of strawberry plants. Consider fumigation if a long-term rotation that excludes the host crops is not feasible.

Sites surrounded by natural bush stands may contain native strawberry plants. These plants can harbour insects, diseases and viral pathogens that may infect cultivated strawberry stands. To maintain good sanitation, it may be necessary to kill native strawberry stands within 400 m (1300 ft.) of commercial strawberry fields.

Water Quality for Irrigation

Irrigation is essential for both consistent, high yielding strawberry production and frost control.

Since the Prairies have fairly low rainfall, and strawberry plants are shallow rooted, supplementary moisture is necessary to maximize production. An average of 30 cm (12 in.) of irrigation water is required over the growing season. Water applications may also be needed for spring frost control and summer crop cooling when temperatures are above average.

River or pond water is often used for irrigation. Well water may be suitable but should be tested to determine if the quality and quantity is satisfactory.

In Manitoba, the suitability of a water source may be tested by submitting a 2 L (0.4 gal.) sample for test number 83 to the Technical Services Lab; Department of the Environment, 745 Logan Avenue, Winnipeg, Manitoba, R3E 1M8. Testing is also conducted by the Water Analysis Section, Saskatchewan Health, B211 Albert Street, Regina, Saskatchewan S4S 5W6, and private labs throughout Alberta. Water quality should be satisfactory for strawberries if salinity is less than 1000 mS/cm, adjusted sodium absorption ratio (SAR) is less than 30 and chlorides are less than 3 meq/L^{-1}.

In the Prairies, a water rights licence is required before water can be taken from any source other than a pond filled completely by rain or snow that has fallen on the grower's property. Construction of ponds or dams may also require approval. Water rights licences are issued by the Water Resources Branch of the Department of Natural Resources in Manitoba and Alberta, and by the Water Corporation in Saskatchewan.

There are a number of assistance programs for the development of irrigation systems. For further details, contact the Manitoba Agriculture, Soils & Crops Branch, the Alberta Agriculture, Drainage Branch of Irrigation and Conservation or the Saskatchewan Water Corporation.

Microclimate

A microclimate is an area with uniform temperature, rainfall and drainage, and good protection from wind. These conditions are essential for successful strawberry production. If the site lacks a microclimate, the grower must create one.

Land that is slightly sloped provides good air and ideal water drainage. Wooded areas should be avoided because frost pockets can develop.

Strawberry plants also need adequate snowfall for winter insulation. Locations subject to lower early spring temperatures or limited snowfall are less than ideal for strawberry production.

Permanent Shelterbelts

If wind protection is lacking, shelterbelts should be planted to reduce wind velocity. Winds can dry fruit and plants during the growing season, desiccate plants during the dormant winter period, remove the winter snow cover and cause soil drifting during the plant establishment year. A properly planted and maintained shelterbelt can assist in obtaining a uniform blanket of snow to insulate plants from winter temperatures.

A number of ornamental plants are suitable for shelterbelts, and each has advantages and disadvantages. Two species that have performed well in Manitoba are Green Ash and Swedish Aspen. For specific shelterbelt recommendations, growers should consult with their local department of agriculture or Prairie Farm Rehabilitation Administration.

Ideally, the hedge should grow quickly, take up minimal amounts of land and produce a minimal amount of shade. Competition for fertilizer and moisture is also an important consideration. When selecting shelterbelt plants, avoid these characteristics:

- over-density of branches inhibiting snow infiltration
- wide spreading top
- high labour requirements for pruning

Above: Annual sunglower shelterbelts are an important ingredient for prairie small fruit production.

Right: One of the purposes of annual shelter is to provide uniform snow distribution over the planting.

- limbs and branches susceptible to breakage from snow, ice and wind
- suckering roots
- high seedling production.

Plant shelterbelts 122 to 183 m (400 to 600 ft.) apart and in a direction that breaks the force of prevailing winds. Do not align shelterbelts so that natural air flow patterns are blocked. This is especially important on slopes, where stagnant air pockets can be created, leading to increased risk of frost.

Weed control, especially of broadleaf types, is a must in shelterbelts. Poorly maintained shelterbelts permit weed and leaf litter accumulations that foster a build up of slug and insect populations.

Annual Supplementary Shelter

On the Prairies, supplementary shelter should be planted every 18 m (60 ft.) or so to enhance the effectiveness of the permanent shelter layout. Corn and sunflower plantings have been used successfully.

When establishing a sunflower hedge, seed at a rate of 9 plants/m (3 plants/ft.) to allow good wind and snow filtration.

Plant as early as possible in the spring. Ensure good fertility so maximum stalk development can take place over the summer. Remove the flower heads before maturity to stop heads from "going to seed" or causing premature breakdown of the stocks. Fully mature heads with seeds will attract birds, an unwanted pest of the strawberry producer. If properly managed, a sunflower hedge lasts several years.

Snow fences, plastic wind screens or lumber slabs can also be used as supplementary shelter. These materials will not compete for moisture and nutrients and permit complete use of a field.

Markets

Market assessment and development are critical components of a successful strawberry operation. Ideal marketing sites are located within 50 km (30 mi.) of a city or large town, or along a tourist/resort route. A rough rule of thumb regarding population per picking area is 4900 people to 1 ha (2000 people to 1 acre). All-weather roads and adequate off-road parking space are also essential to U-Pick marketing.

Fertilizers

The objectives of a fertilizer program are:

- to promote rapid and early runnering of new plants
- to promote rapid growth, development and early runner formation before the end of July
- to maximize crown formation after late August of the establishment year.

Fertilizer rates must be based on sound data derived from soil testing and plant tissue analysis. Estimated nutrient levels or general recommendations are not sufficient for maximum yields. Growers should also pay careful attention to timing and application methods.

Soil Testing

Soil tests should be used to determine the suitability of a field for strawberry production and to guide the ongoing fertility program.

The quality of the laboratory results is as good as the soil sampling procedure used to obtain the sample. For detailed soil sampling instructions, contact your local agricultural office or provincial soil testing laboratory.

Key points to remember in soil sampling are:

- Use proper augurs and clean containers for sampling.
- Sample well before transplanting or renovating to provide sufficient time for the sample to be processed and recommendations returned.
- Sampling depths are 0 to 15 cm (0 to 6 in.) and 15 to 60 cm (6 to 24 in.).
- Do not sample in locations where fertilizers have been recently incorporated.
- Air dry the soil sample immediately after sampling. (This step is often overlooked by growers).

Field Description and Cropping History

This information enables the laboratory to maintain records for research purposes. More importantly, it helps the lab make sound fertilizer and management recommendations for the grower. Over time, individual growers can monitor the fertilizing history and levels of nutrients of their fields.

Soil Test Reports

The following information will help the grower understand and use the results of a soil test report.

Carbonate Content indicates the calcium carbonate content of the sample. High to very high calcium levels in the soil can restrict nutrient availability to the plants. Absence of calcium carbonate does not mean the fields require lime as most prairie soils have sufficient lime. Only very acid soils require additions of lime.

pH indicates the acidity or alkalinity level of the soil. Soils with a pH in the range of 5.5 to 7.5 are usually satisfactory for strawberry production.

pH is important because it influences the solubility or availability of mineral elements required for plant growth. Phosphorus, for example, becomes less available to plants at levels below pH 5.3 and above pH 5.7, while potassium solubility is hampered when levels are above 7.5. Nitrogen is available in the pH 5 to 8 range. Soil pH greater than 7.5 has been associated with yellowing of strawberries caused by the lack of iron uptake in the plant leaf tissue.

Conductivity measures the salinity (salt) level. A conductivity reading of less than 1 mS/cm is best for strawberries. Levels greater than 1 could result in growth problems and reduced yields. Adding lime or gypsum will not correct a soil salinity problem.

Texture indicates the relative amounts of sand, silt and clay. Loam soil is a good mixture of the sand, silt and clay and is neither droughty nor difficult to till.

Nitrogen

Nitrogen is one of the most important elements in strawberry production. Nitrate nitrogen, the form most readily used by plants, is indicated in kg/ha (lb./acre) in soil test results.

High nitrogen rates are likely to increase the number of runners. This could be a disadvantage because too many runners can create high populations and excessive competition. On the positive side, high nitrogen levels in the summer may increase branch crown formation and benefit overall production.

Generally, nitrogen is fairly mobile in the soil and can move into the plant quickly. It can be affected by a number of environmental factors, including rain or irrigation. In saturated soil conditions, nitrate nitrogen rapidly converts to a gas and is lost.

After a planting is established, nitrogen can be broadcast over the entire field or banded over the rows. Banding is a more cost-efficient application method, because the same amount of fertilizer can be used to cover twice as much field area. Nitrogen can also be applied through the irrigation system. (Follow guidelines in "Fertilizer Application" section.) Several applications of nitrogen are more effective than a large, single application.

TABLE 2

Fertilizer Recommendations Based on Soil Test Results

kg/ha (lb./acre)

Nitrate Nitrogen Content 0-60 cm (0-24 in.)		Nitrogen Availability Content	Nitrogen Recommended	
5 - 9	(4.5- 8)	VL	130 - 121	(116 - 108)
20 - 24	(18 - 21)	L	100 - 91	(89 - 81)
35 - 39	(31 - 35)	M	70 - 61	(62 - 54)
50 - 54	(45 - 48)	H	40 - 31	(36 - 28)
65 - 64	(59 - 57)	VH	10 - 1	(9 - 0.9)
Exchangeable Phosphorus in Soil 0-15 cm (0-6 in.)		**Phosphorus Availability Category**	**Phosphorus Recommended**	
0 - 11	(0 - 10)	VL	110 - 102	(98 - 91)
12 - 19	(11 - 17)	L	101 - 96	(90 - 86)
20 - 28	(18 - 25)	M	95 - 89	(85 - 79)
29 - 49	(29 - 44)	H	88 - 81	(79 - 72)
41 - 100	(37 - 89)	VH	80 - 35	(71 - 34)
Exchangeable Potassium in Soil		**Potassium Availability Content**	**Potassium (K) Recommended**	
0-60 cm (0-24 in.)				
32 - 63	(29 - 56)	VL	213 - 165	(190 - 147)
128 - 159	(114 - 142)	L	177 - 165	(158 - 147)
244 - 255	(218 - 227)	M	141 - 129	(126 - 115)
320 - 351	(285 - 313)	H	105 - 93	(94 - 83)
416 - 447	(371 - 399)	VH	69 - 55	(62 - 49)
Soil Sulphate Sulphur Content Sulphate-Sulphur 0-60 cm (0-24 in.)		**Sulphur Availability Category**	**Sulphur (S) Recommended**	
0 - 11	(0 - 10)	VL	30	(28)
11 - 22	(10 - 20)	L	30	(28)
23 - 33	(21 - 29)	M	30	(28)
34 - 44	(30 - 39)	H	0	(0)
45 - 66	(40 - 59)	VH	0	(0)

VL=Very Low; L=Low; M=Medium; H=High; VH=Very High

Rates and Timing for Nitrogen Applications

Timing of nitrogen application has a direct bearing on yield, fruit quality and plant development. Nitrogen applications in late summer often promote flower bud formation for the next year's crop. However, nitrogen application in late fall may delay normal dormancy and cause increased risk of winter injury.

New fields: Nitrogen should be applied and incorporated prior to planting at a rate based on soil test results. (See Table 2 for recommended rates.) When new plants have established their own root system, apply 17 to 22 kg/ha (15 to 20 lb./acre). Make another small application at the early stages of runnering.

Established fields: Nitrogen can be applied at 17 to 22 kg/ha (15 to 20 lb./acre) to an established planting early in the spring. This can be supplemented with foliar sprays, especially if the planting has shown some winter injury.

In most cases, nitrogen applications should be limited during the spring of the fruiting year. Excessive nitrogen in bearing plants favours the development of large, numerous leaves that may hide flowers and interfere with pollination. Also, larger leaves tend to maintain wet conditions near the ground, which promotes fruit rot.

There are exceptions to this rule. For example, heavily mulched plants can lack nitrogen since the nutrient is used by organisms that break down the straw. Under such conditions, applying up to 11.2 kg/ha (10 lb./acre) of nitrogen may increase berry size and yield, provided adequate fertilizers are used at renovation.

Winter injury: Fields that have undergone severe winter injury or that are generally lacking in vigor will respond to a band or broadcast application of ammonium nitrate at 90 kg/ha (80 lb./acre) early in the season.

Renovation: A nitrogen application of 56 to 90 kg/ha (50 to 80 lb./acre) is recommended at renovation time. This key period of "renewal" and fruit bud initiation takes place in mid summer. An additional 17 to 22 kg/ha (15 to 20 lb./acre) can be applied in mid August, the time of flower bud initiation. Applying nitrogen too late in the growing season may delay the plant hardening process, which could result in winter injury.

Phosphorus

This value describes the ability of the soil to supply phosphorus to plants. It is measured in kg/ha (lb./acre). Phosphorus and potassium are measured only at a depth of 0 to 15 cm (0 to 6 in.).

Phosphorus moves slowly in the soil. Its availability to plants depends on soil pH as well as the actual phosphorus content of the soil. Most prairie soils tend to be alkaline, which results in low levels of available phosphates.

This nutrient is especially important for root and seed development so pay special attention to phosphorus requirements when preparing fields for planting. Adequate supplies are needed to promote early production of daughter plants, good vegetative growth and runnering. (See Table 2 for recommended rates.)

Potassium

Potassium readings are measured in kg/ha (lb./acre) and are a measure of the soil's ability to provide potassium to the plant.

Potassium is associated with strong leaf petioles, sturdy fruit stalks and increased winter hardiness. It is also needed for good fruit colour and sugar content.

Sandy soils below 2% organic matter require higher applications of potassium.

Many prairie soils have sufficient potassium to meet plant needs. (See Table 2 for recommended rates.)

Sulphur

Sulphur is measured in kg/ha (lb./acre). The value indicates the amount of sulphate - sulphur in the top 60 cm (2 ft.) of soil.

Sulphur is mobile in the soil. For most prairie soils, sulphur-containing fertilizers like super phosphate and ammonium sulphate provide adequate levels for good plant growth. Higher levels have been found beneficial to lower the pH in some alkaline soils on the Prairies. Some growers use fertilizers containing sulphur so that the equivalent of 56 kg/ha (50 lb./acre) is

TABLE 3

Plant Analysis Values for Determining the Mineral Status of Strawberries

Nutrient	Normal Range	Nutrient	Normal Range
Nitrogen	2.0 - 3.0%	Sulphur	0.15 - 3%
Phosphorus	0.25 - 0.4%	Zinc	20 - 250 ppm
Potassium	1.3 - 2.5%	Manganese	50 - 250 ppm
Calcium	0.8 - 1.8%	Iron	60 - 250 ppm
Magnesium	0.25 - 0.5%	Boron	25 - 50 ppm

used at renovation. These higher rates also provide a slight acidifying affect to the soil. (See Table 2 for recommended rates.)

Micro-nutrients

Micro-nutrients (zinc, copper, manganese, boron, chlorine, iron and molybdenum) rarely affect plant growth. However, the availability of micro-nutrients can be affected by imbalances in soil pH or by uneven application of major nutrients like nitrogen, phosphorus, potassium, and sulphur. These deficiencies may affect plant vigor and berry quality. Field trials have shown yield reductions of 15% where iron is deficient in plants.

Nutrient problems can be overcome through the use of foliar sprays containing the required nutrients. However, nutrient levels should first be verified with plant tissue testing.

Plant Tissue Testing

Plant tissue testing can determine if soil nutrients are being taken up in adequate amounts by the strawberry plant. Even when nutrients are in adequate supply, a plant's ability to use available nutrients can be affected by several factors, including soil temperature, root development, drought, high temperatures, soil saturation with water, fertilizer application methods and timing.

Tissue testing results can help growers avoid long term nutrient problems. Occasionally, severe nutrient problems are encountered early in the growth of a crop. A tissue analysis may allow time for corrective measures to be taken in the same season, thereby reducing the potential loss.

Normal nutrient levels in strawberry tissue vary with plant growth stages such as flowering, fruiting and after fruiting. Tissue values may also be affected by time of sampling, the age of the leaves and the cultivars sampled. However, deficiency levels are reliable indicators that nutrients must be added.

As in soil sampling, the correct procedures for tissue test sampling are important. Key points to remember are:

- Take care to ensure cleanliness in sampling and handling.
- Use proper sampling equipment.
- Take the plant part at the proper time of growth.
- Take a representative sample and immediately clean and dry it with a dry cloth or soft brush.
- Avoid non-typical plants and areas in the field.
- Do not wash the sample.
- Avoid samples that have fertilizer contamination, pesticide residues or soil particles.
- Collect samples in a clean brown paper bag, not a metal container.
- Select the youngest expanded mature leaf as a sample.
- Take 25 to 30 leaves from a reasonable number of typical plants throughout the field.
- Dry the sample at room temperature.

Send these samples to provincial or private tissue testing laboratories. (See section on soil fertility).

Application of Fertilizers

Foliar Application of Fertilizers

Fertilizers may be sprayed on the leaves as a supplement to soil applications. Foliar application brings about a quicker response than soil feeding. It is very useful in "perking up" plants during renovation, or when roots systems suffer from severe winter injury. Generally, any stand that is poor or lacking in vigor may benefit from this procedure. This is particularly the case in third and fourth year fields.

Foliar application has been found to be more successful on lighter soils than on heavier soils that are high in organic matter.

Foliar spraying can be used to apply nutrients like nitrogen or supplementary trace elements such as iron, magnesium, boron and calcium.

Foliar applications are most effective during early growth. The use of surfactants or spreaders, such as soap solutions, can enhance nutrient uptake through leaf tissue.

To avoid leaf burn, nutrient sprays should not be applied during hot weather. Never apply pesticides and nutrients together.

Fertilizer Application Through the Irrigation System

Uniform water application is essential when an irrigation system is used for fertilizer application. Sprinkler operating pressure uniformity can be checked by inserting a pressure gauge in the nozzle. The minimum pressure should be 200 kPa (30 lb./sq. in.). Pressure from nozzle to nozzle should not vary more than 20%.

Fertilizers that can be spread by irrigation include ammonium sulphate, ammonium nitrate, calcium nitrate, ammonium phosphate, muriate of potash, urea and borax. Do not use irrigation to apply phosphoric acid (a corrosive element), anhydrous ammonia (solutions will be lost to the air), or superphosphates and lime (cannot be dissolved in water).

To apply, fertilizer is dissolved in a drum, then introduced into the irrigation line through a valve — either by suction or by pressure — over a 10 to 15 minute period.

After application is completed, continue irrigating for 30 minutes. To avoid burning the foliage, the system must be run until the plants are rinsed with water free of fertilizers.

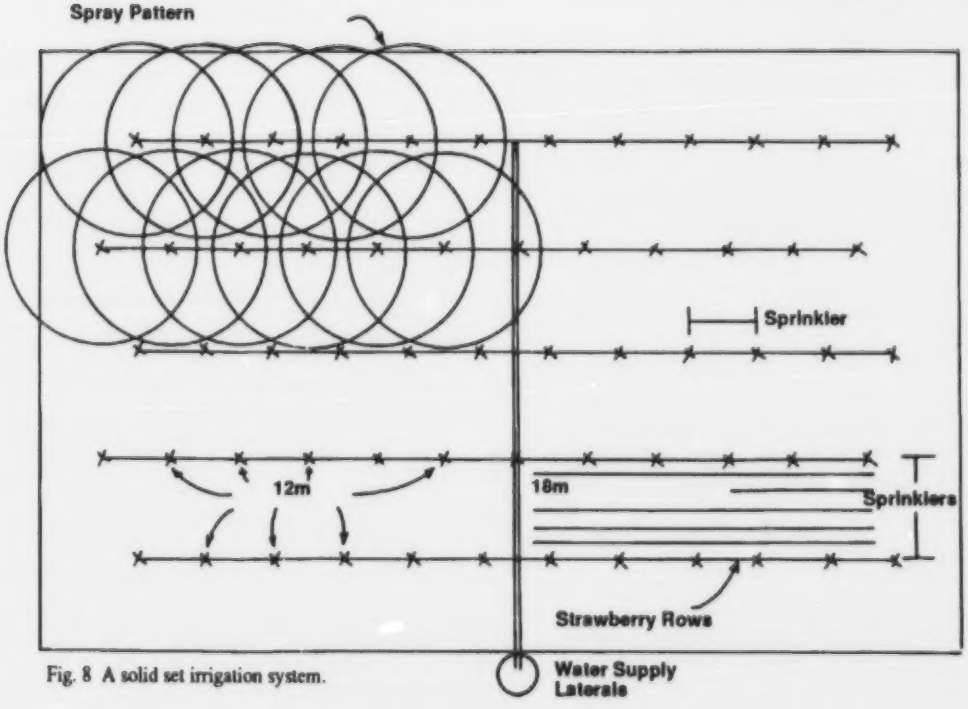


Fig. 8 A solid set irrigation system.

Do not fertilize at the beginning of an irrigation because nutrients may be leached out of the root zone by water applied after the fertilizer injection.

Calculating the Rate

To determine the amount of fertilizer that should be injected into the irrigation system, multiply the area covered by the sprinklers by the prescribed fertilizer rate. For example: At a 12 x 18 m (40 x 60 ft.) sprinkler spacing, 0.02 ha (0.05 acres) are covered by each sprinkler. Twelve sprinklers cover 0.24 ha (0.6 acres). To apply 56 kg/ha (50 lb./acre) of fertilizer for this 12 sprinkler setting, inject 0.24 x 56 = 13.44 kg (29.6 lb.) of fertilizer into the system.

Irrigation

Irrigation helps maximize strawberry yields in several ways. Regular watering produces large plants with large leaf surfaces, which in turn produce more flowers and later, more fruit. The practice also helps establish new plantings and runner rooting.

Irrigation can protect the crop from drought stress – especially during flower bud initiation in the fall – as well as frost damage and extreme heat. Water applications can also reduce damage to young plants and fruit caused by wind-borne soil particles.

Applying water just after straw cover helps anchor the mulch to withstand fall winds. As discussed in the previous section, irrigation can also be used to incorporate fertilizers.

Strawberry field being irrigated by solid set system.

Strawberry-Water Interrelations

Strawberries have a low tolerance to drying and poor drainage because of their shallow root systems.

June bearers have 90% of their roots in the top 15 cm (6 in.) of soil, while day neutrals have 90% in the top 7 to 10 cm (3 to 4 in.). Both types of strawberries may have smaller root zones caused by winter injury or a narrowing of the rows during renovation.

This susceptibility to drought makes irrigation particularly effective for strawberry production. A 2.5 fold increase in yield has been recorded with some cultivars grown under irrigation versus non-irrigated strawberries.

It is most efficient to irrigate early in the day, when evaporation losses can be kept to a minimum. Straw mulch also greatly reduces evaporation from the soil.

Strawberry Irrigation Requirements

Day neutral strawberries may require higher rates of irrigation or more careful monitoring of soil moisture levels because of their shallow root systems. Trickle irrigation on light soils with a black poly mulch may require application rates as high as 5 L/m² (0.1 gal./sq. ft.) per day. Without mulch a rate of 37 L/m² (0.75 gal./ sq. ft.) per day should be sufficient. (Dale and Pritts)

To determine if soil moisture is sufficient, use this hand test method:

- Brush away the dry soil surface.
- Take a handful of the newly exposed soil and squeeze it lightly.
- If the soil ball breaks apart readily as you open your hand, the soil needs water.

A more exact procedure would be to use a soil moisture testing probe called a tensiometer.

Avoid irrigating just prior to picking. Based on a two day picking interval, irrigate immediately after picking with 6 to 8 mm (1/4 to 1/3 in.) of water.

Risk of winter damage may increase when plants are under stress from lack of moisture. Plants should have access to a good level of moisture right up until mulching. The cold hardening process is mainly controlled by the shorter days and cooler temperatures and is not hastened by withholding moisture.

Normal autumn rainfall amounts should be taken into account to avoid over saturation of soils prior to covering.

Take care to avoid excessive irrigation, which can leach herbicides and nutrients out of the rooting zone. Too much moisture can diminish yields, reduce fruit quality and increase fruit rot development.

Key Irrigation Times for Strawberries

Key times for irrigation include:

- establishment
- initiation of berry set
- maximum final enlargement of the fruit
- before signs of wilting occur (otherwise berry size is greatly reduced)
- after renovation of June bearers when fruit buds are forming
- fall, just prior to covering, to reduce risk of winter injury

Other points to consider:

- Excess irrigation leaches herbicides and nutrients from the rooting zone.
- Excess irrigation can reduce yields, reduce fruit quality and increase fruit rot development.

Selecting an Irrigation System

Strawberry growers can choose from several irrigation systems and accessories. Factors to consider are site, investment cost, labour requirements and suitability of the system for the crop.

Trickle, pivot and large gun systems will apply water but are not suitable for frost control. Well designed systems have the proper size of sprinklers, pipelines, pumps and filters, are well laid out and are able to meet the needs of the crop. Consult an irrigation specialist or your local irrigation equipment dealer for details on systems and layouts.

A balance should be maintained between pipe costs and power costs. The larger the diameter of the pipe, the higher the investment cost. While smaller pipes are less expensive to purchase, more energy is required to pump the water due to increased water friction.

Planning an Irrigation System

A basic plan should contain the following:

- a map showing the field boundaries and water source location
- lift to deliver water to the field
- location of natural gas and electrical power lines
- highest and lowest points in proposed irrigated area
- kind and depth of soil profile
- rate water enters the soil
- water-holding capacity of the soil
- amount of water available for irrigation
- power source
- labour requirements - operation, maintenance and moving of system

A Solid Set Irrigation System for Strawberries

A solid set irrigation system is designed to apply water uniformly over the entire crop at one time. This type of system is expensive but can be operated without labour during the irrigation season. A solid set system can be used for frost control, and crop cooling, and can be adapted to irregularly shaped fields with topographical variation. Figure 8 shows a sample layout.

Components

A solid set system basically consists of:

- a main line
- lateral lines
- sprinkler heads
- risers
- pump
- power unit

Main Line - Aluminum pipe is used for an above-ground main line, while PVC pipe is used for a buried main line. The diameter of the line can range from 15 to 30 cm (6 to 12 in.).

Laterals - Aluminum pipe with ranging from 5 to 10 cm (2 to 4 in.) in diameter is used. Coupling types used to connect the pipe vary between companies and generally are not interchangeable. Spring couplers are not ideal if the system is moved regularly. Rubber gaskets inside the coupler seal the line against leakage while the system is operating. Self draining couplers prevent rupture due to freezing but are not suitable for fertilizer application.

Laterals are normally spaced 18 m (60 ft.) apart, with sprinklers placed every 12 m (40 ft.) along the lateral. This is commonly referred to as a 12 x 18 m (40 x 60 ft.) pattern (see Photo 4). Depending on the sprinkler selection, a 12 x 18 m pattern should give a reasonably uniform water application when wind is less than 16 km/h (10 mph). At windy sites, a 9 x 12 m (30 x 40 ft.) spacing will provide more uniform water application.

Sprinkler Heads - The rotary sprinkler operates on the principle of an impact arm which is deflected by the jet of water from the nozzle. A spring under tension returns the arm to the original position causing an impact of the arm against the sprinkler body which results in rotation of the head.

If a system is operated below 10°C (50°F) degrees, ice can build up on the sprinkler heads and prevent the heads from rotating. Plastic heads can be more prone to ice buildup than metal heads.

An application of 2.5 to 3 mm/h (1/10th to 1/8 in./h) of water is required to control frost damage to plants. This requires a minimum of

one revolution of the sprinkler per minute with the system described.

Ideally, the sprinkler should have one nozzle open and the other tip plugged. When both nozzles are open, excessive amounts of water may be applied and the smaller nozzle opening may plug with debris.

Sprinkler heads should not be placed opposite each other on the laterals that run side by side. Rather they should be offset, forming a triangular pattern. This pattern does not appear to be distorted as easily by wind.

Be sure sprinkler heads at the ends of laterals provide adequate coverage to the field perimeter.

A 5 cm (2 in.) diameter lateral can support up to 16 sprinklers. As a general rule, the difference in operating pressure between sprinklers should not exceed 20% of the operating pressure. For an application of 3 mm/h (1/8 in./h) using an 12 x 18 m (40 x 60 ft.) sprinkler pattern, the water flow per sprinkler should be approximately 11 L/min. (3 gal./min.).

A 12 x 18 m (40 x 60 ft.) sprinkler pattern would require 46 sprinklers per ha (18 per acre).

Risers - The sprinklers are connected to a riser pipe that attaches to the lateral pipe couplers. Risers range in length from 15 to 60 cm (6 to 24 in.). The ideal height is 30 cm (12 in.). Higher risers interfere with field sprayer booms and other field equipment.

Pump - A very reliable pumping system is essential, especially when water is needed to control frost.

It is questionable whether PTO pumps can provide the trouble-free reliability needed for frost control, although PTO pumps and several hand-move laterals may provide an inexpensive irrigation system for the establishment year.

For an application of 3 mm/h (1/8 in. /h), the minimum pump capacity required is 500 L/min./ha (44 gal./ min./acre). Select a pump that provides the required flow at a pressure sufficient to efficiently operate the sprinkler where the pressure drop in the system is greatest. This must take into consideration the line losses and head requirements.

Economic Irrigation Considerations

A solid set irrigation system costs about $6200/ha ($2500/acre). No return on investment can be expected in the establishment year unless the planting is a high density June bearing or day neutral type. In these cases, cash flows are generated in the planting year. The normally high capital costs of a solid set system can be delayed until the spring of the picking year.

Less costly alternative systems like the big gun, hand moved lateral and trickle systems can be used in year one.

Cost of operation is also a factor to consider when planning the system. For example, internal combustion engines require monitoring for refilling. Electricity as a power source is less costly to operate but may be expensive to install at sites that cannot readily be accessed by three phase power.

Special Applications of Solid Set Irrigation

Radiation Frost and Freezing Injury

Day neutrals can be grown as an annual with little regard for spring frost damage to the flowers. However, extending the harvest period beyond the natural first fall frosts by using irrigation for frost protection, can be economical.

Radiation frost occurs on clear, cool, calm and relatively dry nights in the spring when the air temperature near the ground drops below the freezing point. Plant tissues freeze as heat is lost from the leaves, flowers and fruit.

A second weather phenomena, differing from frost, is a freeze. This occurs when cool air masses move into the area, taking heat away from the plant by convection.

Frost damages the center of the flower. The center turns black while the petals and leaves appear uninjured. The blackening occurs within a few hours to one day after the frost. Frost can also damage the developing fruit, deforming the berries.

Frost injury rarely causes complete crop loss because the strawberry plant produces flowers over a two to three week period. The first flowers to open are the largest and face the greatest risk of frost injury. Closed buds are

also sensitive to frost damage. Frost losses can range from 20 to 80% depending on the temperature and the duration of the frost, the cultivar, vigor, stage of development and the weather preceding the frost.

Ground level temperatures can be two to three degrees cooler than temperatures reported by Environment Canada, which are taken at shoulder level. Therefore, thermometers or electronic temperature alarms should be located in low spots where frost would usually occur first.

Mild frost damage can be controlled by management practices other than solid set irrigation. These include not tilling the soil during the frost risk period in early spring. Untilled soil acts as a heat sink during the day and this heat is released during the night to protect the plants. Irrigation prior to a frost will provide an increased heat release from the soil by conductivity. The use of polyethelene covers will reduce damage to flowers caused by light frosts and cold winds.

The Frost Control Principle and Frost Injury Levels

As water freezes, heat is released, keeping the plant parts above the freezing point. This frost control method is effective down to about -6.6°C (20°F). The key to utilizing this principle successfully is to leave the irrigation system operating until after sunrise to ensure that the ice will melt.

A temperature of -1°C (30°F) at the plant level may cause slight injury to open flowers. A medium injury to open flowers can be expected at -2°C (28°F). Temperatures below -3°C (26°F) at the plant level will cause severe injury to buds and developing berries.

Key tools for frost control include an automatic thermal alarm, several probe sensors or thermistors and several accurate thermometers. The thermistors are placed in the flower buds of two random plants, preferably with one plant located in a low area of the field and the other beyond the frost protection system. The thermometers should be placed at the thermistor locations as a double check. A comparison of the readings at the two sites will help determine when to stop the irrigation system. These are the key steps for frost control:

- Start the sprinklers just before the air temperature at ground level reaches 0°C (32°F).
- Apply 2.5 to 3 mm/h. (1/10 to 1/8 in./h.). At this rate, 655 to 822 L/ha (60 to 75 gal./acre) of water is applied.
- Do not stop when ice begins to form on the plants.
- Operating time needed to control frost varies from three to fifteen hours, but usually takes eight to ten hours. A slight breeze or cloud cover during the night may temporarily raise the temperature above the freezing point, but the temperature can drop below freezing just as quickly if conditions change.
- Ice may form anywhere from 1.5 to 12 mm thick (1/16 to 1/2 in.) depending on the intensity and duration of the frost. This does not seem to injure low growing strawberry plants.
- Leave sprinklers on until the temperature increases enough to start melting the ice that has formed.

For specific steps in frost control see section on the care of established planting.

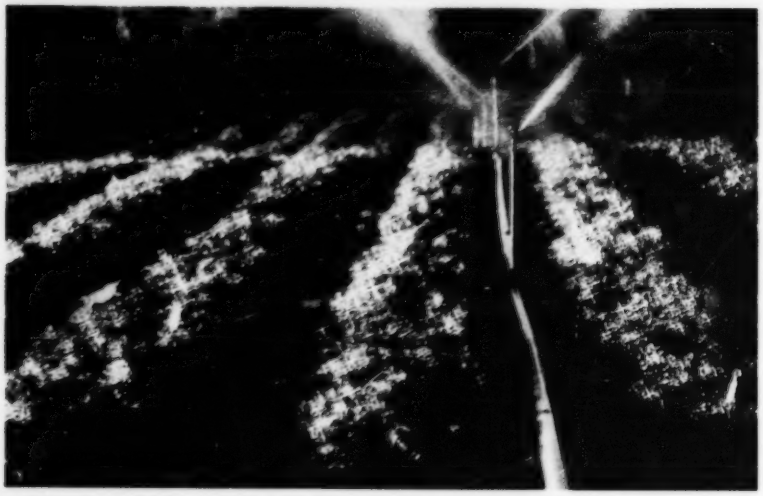
Frost Control Using Less Water

Growers with limited water supplies or poorly drained soils can achieve frost control by applying water at intervals starting at air temperatures slightly below 0°C (32°F). This delay in starting up the irrigation can reduce the water used for frost control providing careful temperature readings are taken. This method is based on the theory that cell salts allow lower temperatures to occur within the cell without causing freezing damage. Since bud temperatures are 1 to 2 degrees warmer than freezing air temperatures, irrigation can be initiated later. This can reduce the time the irrigation system is in operation for frost control.

Water requirements for frost control can be reduced up to 50% by:

- monitoring the internal bud temperatures using a thermistor placed in the bud
- delaying the starting time of irrigation until the internal bud temperature is close to critical temperatures (-2.2°C or 28°F) rather than using the air temperature (0°C or 32°F)
- applying irrigation at varying intervals, based on the length of time it takes for water film to freeze on the buds
- stopping irrigation at sunrise.

Environmental conditions like high winds during a frost can hinder the effectiveness of



Frost Control - a layer of ice and water prevents blossom freeze.

frost control practices. The key is to maintain a film of water on the bud at all times and no injury will result (Dana).

Wind machines can only be used successfully under temperature inversion conditions, when a warm air layer lies over a cold air layer on the ground. A radiation frost will more often be the cause of damage to strawberry flowers on the Prairies.

Crop Cooling

Light irrigation will cool crops and may lead to better yields. The final enlargement of the fruit can occur only when there is a minimum of water stress on the plant because moisture is needed to fill the cells of the fruit. Under hot, dry conditions, water may move out of the fruit into the leaves, resulting in smaller size and lower quality fruit. This condition is called Sunscald. The frequency of irrigation during the harvest season can affect berry size, appearance and sweetness. In experiments where small quantities of water were applied in eleven irrigations during the harvest season rather than in two widely spaced irrigations, berry yield increased from 9.8 to 16.1 t/ha (4.4 to 7.2 tons/acre) and the berries were 86% larger in size. They were more attractive and held longer in storage but were not as sweet as those produced using the two irrigations.

Irrigation for air conditioning or crop cooling should be applied around noon on hot, dry days when temperatures reach 30°C (86°F) and relative humidities are below 30%.

This procedure lowers the leaf temperature, raises the relatively humidity of the air and reduces the transpiration rate and water stress on the plant. Plants require small amounts of water spread over several applications. Generally, rates of 2 mm/ha (1/10 in./acre) of water for two or three hours are sufficient. Where nozzle size does not permit a low application rate per hour, higher application rates per hour can be used if time of application is kept short and repeated periodically throughout the hot portion of the day.

Pesticide Injection

There are no registrations for pesticide injections through irrigation systems in Canada. This practice is not recommended because back flow contamination to the water source is a serious danger. As well, the efficiency of this pesticide application method is questionable.

Fumigation Seals - Soil sterilants such as Vorlex, Mylone, and Vapam are volatile but can be sealed in the soil by applying 12 mm (1/2 in.) of water immediately after the fumigant is applied. This, along with compaction, will seal the chemical into the soil.

Trickle Irrigation

Most strawberry growers use solid set irrigation because of the frost control and air conditioning potential of this system. However, trickle irrigation can be used successfully when growing late flowering cultivars, when water supplies are limited, or when flow rates are low.

Four advantages of trickle irrigation are high efficiency of water use, water patterns that are unaffected by winds, ease of fertilizer injection and low initial capital cost ($1976/ha or $800/acre).

Disadvantages of trickle irrigation include risk of damage caused by field equipment and rodents, as well as a higher depreciation rate compared to a solid set system.

Components of the trickle irrigation system include: pump, filter, main line, subline, laterals and emitters. Plastic is usually the main material with a linear tape system. The tapes have hole spacings 30 cm (12 in.) apart. The most critical part of an efficient trickle irrigation system is the filter because organic material and precipitates can plug the emitters.

New Plantings

Above: Establishing day neutrals with black poly mulch.

Below right: Established matted row of day neutrals.

Below far right: Ripening day neutral fruit.

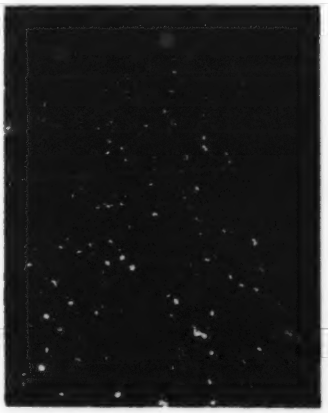
Cultivars

The cultivar choice depends on:

- yield
- hardiness
- disease and insect resistance
- consumer acceptance

The performance of a cultivar at a particular site can be affected by soil type, management skills and climate.

Some cultivars are widely adapted in the prairie area. Red Coat, for example, is noted for its winter hardiness in some parts of the Prairies. However, since the introduction of new cultivars over the past decade, Red Coat is being replaced by varieties with similar hardiness but higher fruit yield and quality.



In selecting a strawberry cultivar for a particular farm, growers should consult their local variety test results. Cultivars respond differently to minor climatic and soil conditions, so growers should test cultivars prior to wide scale adoption. Only those that do well should be selected for their farm situation. A blend of early, mid and late season cultivars can extend the harvest period and spread risk.

Everbearers

This type is not recommended for commercial production because:

- Cost of production per hectare is high with more plants and hand labour required.
- Ability to produce runners is limited.
- Fruit quality is inferior.

A high yielding cultivar with large fruit but poor shelf life is Fort Laramie.

Day Neutrals

Based on yields, Fern, Hecker and Tristar have a proven track record on the Prairies.

Fern

- medium to high yielding
- good hardiness
- attractive, firm fruit
- good texture and flavour
- not strong vegetatively

Hecker

- high yielding potential
- good hardiness
- medium vegetative characteristics
- attractive fruit
- good texture and flavour

Tristar

- medium yielder
- good late season producer
- very good hardiness
- medium vegetation
- firm fruit, very good flavour and texture

June Bearers

The following varieties have performed well on the Prairies:

Kent

- one of the highest yielding varieties in tests conducted across the Prairies
- mid season, slightly later than Red Coat
- good hardiness
- medium to high vigor
- large to medium fruit with very good, firm texture and flavour
- somewhat susceptible to Sinbar injury
- tolerant to hot summer temperatures, but

does not stand well under wet harvest conditions
- preserves well by freezing

Glooscap

- glossy, attractive, firm fruit
- potential for high yield
- very good vigor
- good flavour
- similar to Kent in maturity
- good for freezing and fresh market
- good shelf life

Red Coat

- very winter hardy except in Alberta
- ripens in mid season
- berries are medium firm, uniform in size, medium red in colour, maintain size well, and retain attractiveness after storage
- flavour is only fair
- light internal colour, especially if picked prematurely
- plants are strong and runner extensively
- susceptible to Verticillium wilt
- resistant mildew
- yields below Kent and Glooscap

TABLE 4
Plant Nutrient Values of Manure

		Kg/t of Manure			lb./ton of Manure		
Type of Manure	Quality	N	P_2O_5	K_2O	N	P_2O_5	K_2O
Cow	Good*	2.5	1.5	4	5	3	8
	Poor**	1.0	0.5	3	2	1	6
Poultry	Good*	5.0	3.0	4	10	6	8
	Poor**	3.0	2.0	3	6	4	6

NOTE: *well rotted, but not leached; ** excessively rotted & leached.

Honeoye

- mid-season
- very good hardiness and vigor
- medium to large fruit which tend to have a white tip when ripening
- attractive
- not as firm as Glooscap
- good texture and flavour
- consistently productive

Bounty

- late season variety
- medium to high yield potential
- good hardiness
- medium vigor
- medium to large fruit, especially in early stages
- attractive and firm
- very good texture and flavour

Other Cultivars

The following varieties have performed less consistently throughout the Prairies than those previously listed:

Gorella, Micmac, Northland, Protem, Sparkle, Trumpeter, Vantage, Veegem, Veeglow and Veestar

New Cultivars

New cultivars showing better disease resistance, fruit characteristics, specific environmental tolerances and yield increases are being released periodically. Both day neutral and June bearing crosses are presently under test. Growers are cautioned to try only a small planting before adopting new cultivars for general production at their site.

Care of Nursery Plants Prior to Planting

Plants will keep in storage at 1° to 3.3°C (34 to 38°F) for up to two weeks. Once temperatures rise above this level, rot develops and drying occurs more quickly. Do not refrigerate plants that have initiated any growth. Temperatures of 4.4° to 10°C (40° to 50°F) can be permitted temporarily, provided the plants are checked frequently for mold development.

Take plants out of cold storage the day of planting and cover them with a tarp until they are to be planted. Plants should be watered to keep the roots from drying out during planting. A cold, cloudy day is preferred to a hot, windy day for planting.

For temporary storage, plant crates should be put in a shaded, cool location and covered with wetted burlap bags. If planting must be delayed and cold storage facilities are unavailable, keep plants as cool as possible and check for mold periodically. Plants can be safely kept for seven to ten days in this manner.

Above: Site preparation, an important first step for four year crops.

Right: Improving the soil texture and controlling weeds with green manure crops.

For longer periods, plant bundles should be separated and put in a shallow, V-shaped trench, with roots spread out and crowns covered at ground level with soil. Firm soil slightly around the roots and leave plants in this condition until the field is ready for planting. Locate plants in a well drained area, sheltered from the sun and wind.

Avoid plants from bundles that have grey mold on the roots when they are unpacked. Discard plants with mold development on the upper root and lower crown areas.

Soil Preparation

Once the planting site has been selected, proper preparation is needed. This generally takes two years. Land preparation is critical in terms of soil tilth and perennial and annual weed control.

Soil preparation has three main objectives:

1. To destroy as many weeds as possible, especially perennials such as thistle and quackgrass.

Growers attempting to short-cut this basic production rule will have a continuing battle controlling weeds. For chemical weed control recommendations, contact the local agricultural representative or weed supervisor.

2. To add as much organic material as possible.

At least 40 t/ha (18 tons/acre) of barnyard manure should be added to the field. Well-rotted manure should be incorporated in the spring of the year before planting to permit straw to break down. Apply poultry manure well ahead of planting at a maximum of 11 t/ha (5 tons/acre) to avoid burning strawberry roots. (See Table 4).

Growing a green manure crop a year before planting is also a good practice. The residue increases organic matter and helps improve soil tilth, overall structure and water retention capacity. Suitable green manure crops are rye seeded at 125 kg/ha (2 bu./acre) or buckwheat at 81 kg/ha (1.5 bu./acre). Apply 56 kg/ha (50 lb./acre) of actual nitrogen so the field is as fertile as possible.

Green manure also increases beneficial soil bacteria that provide for a slow release of nitrogen and trace elements to the strawberry plants.

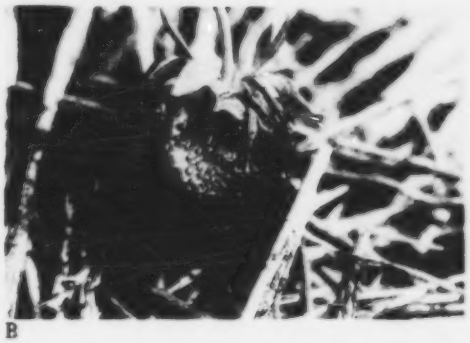
Green manure crops should be sown as early as possible and ploughed under in late summer to allow time for the incorporated crop residue to break down in the soil.

3. To ensure organic matter is well decomposed. Work soil in the fall to get a deep and reasonably loose planting bed. A rototiller or other suitable equipment can be used. Some growers find plants grow better if placed in soil that has not been disturbed by spring tillage. This may be directly related to soil moisture.

Fertilizer Recommendation Before Planting

Apply and incorporate fertilizer as recommended by the soil test, paying close attention to phosphorus content. Depending on the fertilizer type used, sulphur may or may not be included in the mix. Preplant herbicides may also be incorporated at this time.

C



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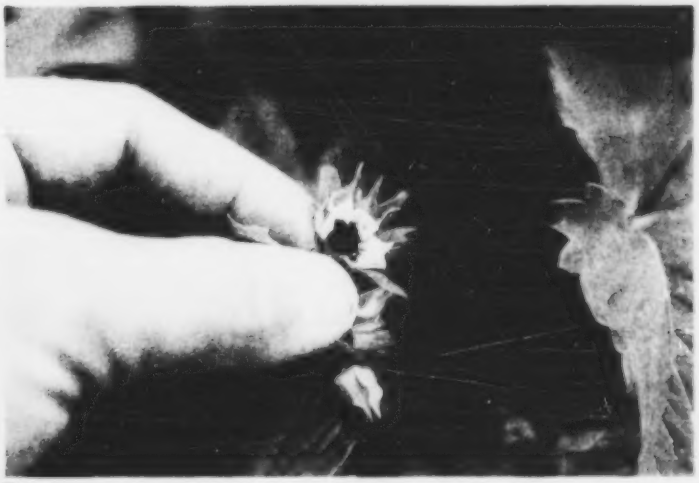


F

E

G

A Yellowing in strawberries (iron chlorosis).

B Sunscald fruit often found on west or south side of the row.

C Poor pollination can create berry deformity.

D Nitrogen deficiency in strawberries.

E Potassium deficiency in strawberries.

F Frost damage to the flower.

G Sinbar damage to strawberry leaves.

H Winter damage to the crown. Note brown tissue.

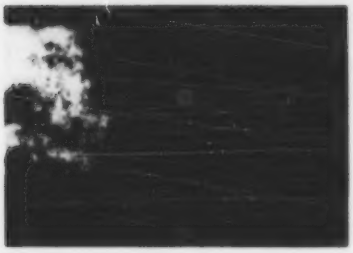
I Cyclamen mite damage to foliage.

J Aphids feeding on strawberry leaves. Also may carry insect viruses.

H

I

J



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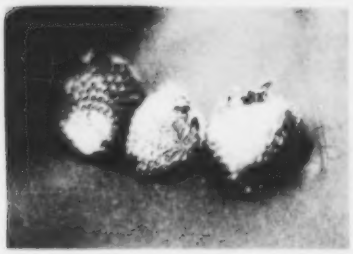

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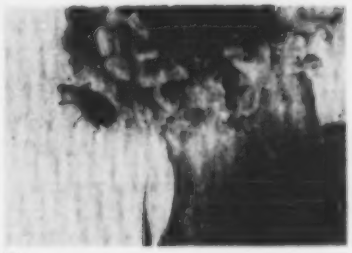


N

L

K

K Slugs can cause severe fruit damage and present a poor farm image to customers.

L Strawberry crown borer damage to a field can be devastating.

M Strawberry crown borer larvae feeding inside the crown.

N Adult strawberry "clipper" weevil.

O Strawberry clipper weevil damage to a flower stalk. Losses can be high and occur very quickly.

P Adult tarnish plant bug (copper brown) unlike the green nymph phase.

Q Tarnished plant bug damaged fruit. The number one insect problem.

R Leaf spot on strawberry leaves.

S Grey mold infected fruit.

T Leather rot infected fruit.

TABLE 5

The Number of Plants per Hectare/Acre Required at Various In-Row and Between-Row Plantings

Spacing in the Row (m)	Between the Rows (m)	Approximate Number of Plants/ha	Spacing in the Rows (ft.)	Between the Rows (ft.)	Approximate Number of Plants/acre
0.081	1.07	123,001	0.25	3.50	49,783
0.15	1.07	62,305	0.50	3.50	24,891
0.24	1.07	38,941	0.80	3.50	15,555
0.30	1.07	31,153	1.00	3.50	12,446
0.46	0.90	24,420	1.50	3.00	9,680
0.46	1.07	20,317	1.50	3.50	8,297
0.46	1.20	17,819	1.50	4.00	7,260
0.61	0.90	18,015	2.00	3.00	7,260
0.61	1.07	15,321	2.00	3.50	6,223
0.61	1.20	13,437	2.00	4.00	5,445
0.76	0.90	14,459	2.50	3.00	5,808

Planting Steps

Always buy certified plants when starting a new planting. Plant quality has a direct bearing on the plant's eventual performance and yield.

Plant as early in the spring as soil condition will permit. Planting into wet soil will result in poorly set plants which will decrease survival. Certified plants cannot be expected to perform at their best with improper handling and poor planting conditions.

Short rows make thorough picking easier to manage, while long rows facilitate cultivation, spraying and other field practices. Generally, a row should not be longer than 10 sprinkler head spacings or approximately 122 m (400 ft.). The use of cross aisle-ways allows for easier picker management of long rows. Align rows for efficient layout of irrigation pipes.

It is very important to apply water to the young transplant after planting. Waiting for several hours can reduce plant vigor for several years after establishment.

Plant rows so they fall within the irrigation spray pattern. Avoid planting too close to shelterbelts because of shading and competition for moisture and nutrients. Depending on the shelterbelt species, the distance from the shelterbelt to the first row of strawberries may range from 15 to 30 m (50 to 100 ft.).

Starter Solutions

Fertilizers high in phosphorus, such as 10-52-17 or 10-30-10, can be added to water applied during transplanting. Dissolve the fertilizer at the rate of 0.5 kg/455 L (1 lb./100 gal.) of water and apply this solution at 0.14 L (5 oz.) per plant. Some mechanical planters automatically apply starter solution to each plant.

When fertility is adequate, water alone may be sufficient to provide the transplants with a good start.

Planting Distance

Strawberry rows are planted 1.2 to 1.5 m (4 to 5 ft.) apart, with plants about 46 cm (18 in.) apart in the row. The prairie growing season is short and closer planting in the row helps establish a full matted row in the first year.

If the width of the picking row is kept at 30 to 40 cm (12 to 15 in.), a planting distance of 0.9 to 1.1 m (3 to 3 1/2 ft.) between the rows can be used. For a picking row width of 60 to 76 cm (24 to 30 in.), a between-row distance of 1.2 to 1.4 m (4 to 4 1/2 ft.) is required. (See Table 5)

Day neutrals are usually planted in double rows 15 cm apart (6 in.) with 1.5 m (5 ft.) between rows. This provides a population of 42,000 plants/ha (17,000 plants/acre).

Planting Depth

Set each plant so the mid-point of the crown is level with the soil surface (Figure 9) When plants are set too deeply, rot may develop and runnering will be delayed and reduced. If plants are set too shallow, the crown and the top portion of the root can dry out, reducing the potential for rapid establishment. Most plants are machine planted. Adjust the machine so plant roots are placed in a vertical position in the soil. Roots longer than 15 cm (6 in.) may be trimmed to that length. Always have someone follow the transplanter to check planting depth and to reset any plants not properly planted.

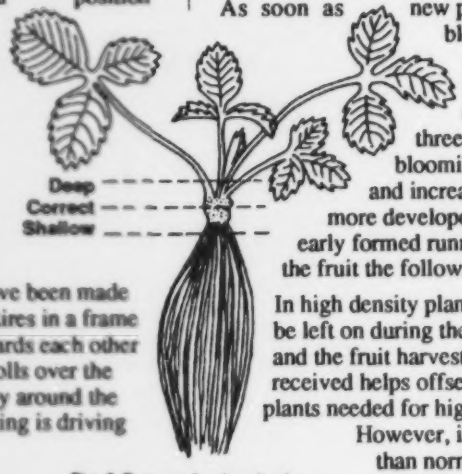


Fig. 9 Correct planting depth.

Growers have designed several machines to firm soil around newly-planted strawberry crowns. Packers have been made using two wheels with rubber tires in a frame which inclines the wheels towards each other at the bottom. As this packer rolls over the planted row, it firms soil tightly around the roots. Another method of packing is driving an all terrain balloon-tire tricycle with its middle tire over the planted row. The wide, low-pressure tire is ideal for firming soil around the new transplants without causing damage.

A small "shot" of water or soluble fertilizer solution at the time of transplanting is beneficial when soil moisture is low. Applying too much water will cause the roots to float up before being covered with soil, creating a "J-root" placement as opposed to a properly fanned-out placement. A light cultivation is recommended to replace soil around the crown after soil has settled because of watering or wind erosion. This "hilling" process works well with lighter soils. However, be careful not to bury the crown when hilling with heavier clay soil types.

Transplanting with a three row planter.

Care of the Young Plant

Productivity over the life of the planting, especially the yield of the first bearing year, depends on the establishment of a fully matted row in the planting year.

As soon as new plants begin blossoming, remove the flower stalk. It may be necessary to go over the field two or three times. This de-blooming results in earlier and increased runnering plus a more developed root system. These early formed runners will bear most of the fruit the following year.

In high density plantings, blossoms may be left on during the establishment year and the fruit harvested. The income received helps offset the extra cost of the plants needed for high density plantings. However, if the planting is later than normal or plants experience any stress, fewer daughter plants will form. This results in reduced yields and vigor over the life of the planting.

Avoid herbicide applications until plants are fully established, usually a period of four to six weeks. Ensure the planting is vigorous before herbicides are used in the establishment year.

During this time, cultivation and hand weeding are necessary. Cultivation should be no more than 2.5 to 5 cm (1 to 2 in.) in depth. Cultivating in the same direction each time will tend to move runners toward the row to form the desired mat of plants. This process will disturb the runners less and allow them to set faster. Cultivating too close to strawberry plants will disrupt the root system. Remove any soil that has flipped up on to the plant crowns. Hand weed or hoe any weeds not killed by the cultivator. For current chemical weed control recommendations, obtain the latest edition of the Guide to Weed Control for your province. Follow the recommendations closely and use only chemicals registered for use on strawberries in the Prairies. Be aware of the residual effect of some herbicides

Above: Establishing the matted row with the early formed runners.

Right: Controlling the matted row width by removing late formed runner.

Below: Straw covering for winter protection with a "Bale Buster".

recommended for weed control in strawberries. This is especially important on lighter soils and with certain strawberry cultivars.

Fertilization After Planting

If plants grow slowly and have small, light-green leaves, 17 to 22 kg/ha (15 to 20 lb./acre) of actual nitrogen should be side-dressed or placed directly on the row. Repeat the application one month later if no response is seen after the first application. If fertilizer is applied to the surface, ensure foliage is dry and brush all fertilizer pellets off the plants by dragging burlap or a light chain over the row behind the applicator. In late August, apply 28 to 56 kg/ha (25 to 50 lb./acre) of actual nitrogen to help fruit bud formation.

Spray Program in the Planting Year

New plantings are subject to insect and disease damage, especially if the fields are adjacent to established strawberry plantings. Control measures based on periodic monitoring should be undertaken according to current recommendations.

Healthy, vigorous green foliage is required throughout the growing cycle. This includes the fall period when some fungus leaf spots can significantly reduce the plant leaf surface, thereby reducing the potential for storage of carbohydrates necessary for winter survival.

Management of Runners

The special care given to establishment of runners will dramatically increase yield potential in the bearing year.

Primary runners that are hand-set early will out-yield secondary and tertiary runners 14 to 1. Quaternary runners usually do not root deep enough to develop significantly by the end of the season. Once the row is full, the extra runners may be cut off. Use a rolling coulter attached to the cultivator to facilitate their removal. The plantation needs frequent irrigation at runnering time. If soil is moist, runners will develop enough root and top growth by the end of the season to survive the winter. No renovation is required in a first year planting. Renovate after the first full picking season and each subsequent picking year.

Irrigation of a Young Planting

For rapid plant development, maintain a uniform moisture level in the soil at planting time and during the initial establishment period. Do not saturate soil with moisture and keep in mind the potential for rainfall. During runnering, soil moisture at a depth of 1 to 1.3 cm (0.4 to 0.5 in.) should be at least 74% of field

Above: Straw removal in the spring with a side delivery rake.

Right: A high pressure sprayer is one of the most important tools for strawberry production.

capacity to facilitate rapid daughter rooting.

Mulching

Mulching with straw, or plastic and straw, is necessary to protect the crop from low temperature injury to crowns and roots. When properly applied, mulch keeps soil temperatures more uniform, prevents plants from drying out from cold and dry winds, and helps trap snow. Mulch is usually applied in late fall after several frosts but before temperature drops to -6.7°C (20°F). Timing varies with prairie location but mulch is usually applied between late October and early November. Avoid heavy applications. High slug populations have been associated with over-mulching.

Mulch may blow off sites that are not properly sheltered, particularly if a combination of straw and plastic mulch is used. A slight wetting through irrigation will help keep the mulch in place. On a calm day, apply fresh, dry straw. This material will lie loose and fluffy and provide a good insulation layer. Straw should be sticking up to trap the snow, rather than lying flat.

Wheat or oat straw is the best mulch material for the Prairies. Use straw from grain fields that are as weed-free as possible. From 4.6 to 6.7 t/ ha (2 to 3 tons/acre or 120 small bales) are required. The mulch layer should be 5 to 8 cm (2 to 3 in.) thick after settling. Applying a thicker layer of straw does not provide a proportional increase in insulation. Trapped air spaces in the straw layer provide the insulation for good winter protection. The straw spreader should apply an even cover over the entire area and should not chop the straw into short lengths.

A straw spreader-applicator called the "Bale Buster" can apply straw directly to several rows at a time, from large round bales. The only labour required by this system is one person to drive the tractor and load the machine with the large bale. Many growers have reduced the investment in a straw spreader by building their own machine.

A herbicide should be applied just before mulching to provide weed and volunteer grain control in the spring. For specific recommendations, consult your local chemical weed control bulletins. Delayed mulch removal in the spring can set blooming back several days. This adversely affects yield and the future survival potential of plants. With a plastic and straw mulch, delayed removal is even riskier.

Moving the straw mulch between the rows in the spring helps keep berries clean, conserves moisture, suppresses weeds and provides a pleasant picking area.

Plastic Mulching

With certain cultivars and in low snow cover conditions, winter survival may be improved by applying a 1.5 mm layer of clear plastic film before plants are covered with the straw. The plastic can be applied several weeks before straw is spread in late October. In early April, the plastic must be removed or "slit" to prevent plant damage caused by increased temperatures under the plastic.

This technique has improved winter survival and normally advances harvesting by seven to ten days. However, early spring plant development may require more frost control measures. Also, straw is more likely to blow off windy sites if plastic mulch is used.

A healthy matted row in full bloom.

Growers should experiment with the technique before adopting the practice on a full scale.

Mulch Removal

Remove mulch in the spring as new growth begins and new leaves become a light yellow colour. This normally will occur between mid April and early May for most prairie locations. It is especially important to remove plastic mulch, which should be taken off at least two weeks prior to straw mulch. Remove mulch earlier if the soil is wet.

Remove excess straw from the rows and aisles with a side delivery rake.

Rotary mowers are also an excellent way of removing straw. The rotating blades place the straw into the aisles. Two passes over the rows will do a complete job.

A beet top flailer is another machine used for straw removal. Fairly accurate adjustments can be made to the topper to allow partial removal of the straw.

Partial mulch removal delays development without harming plant growth. This practice can be used to delay bloom development and avert early frost damage to mature blooms.

Spray Program for the Picking Year

Insecticides or fungicides should only be applied when insect populations and disease infections reach levels that would adversely affect profits. Eradication of all pests is not the goal of pest control.

Growers should become familiar with the life cycles of strawberry pests, know how to detect their presence and inspect fields periodically. For example, many pests overwinter in leaf litter in the row and start their activity even before straw removal. Plants suffering winter injury or stress appear to be more prone to injury by insects and disease, and therefore require careful monitoring.

The tarnished plant bug, strawberry weevil or strawberry clipper can cause serious yield reductions by damaging the fruit. For more information, see the section on Disease and Insect Control.

Spring Fertilizer Applications

Apply 11 kg/ha (10 lb./acre) of nitrogen to bearing fields after flower buds have started to form. Excessive nitrogen levels result in overly vigorous leaf canopies that interfere with pollination and fruit quality. For more information, see the section on Fertilizers.

Pollination

Lack of proper pollination is one of the major causes of deformed berries.

Deformed berries are caused by:

- slight frost injury to blossoms
- injury from tarnished plant bugs
- lack of proper pollination.

Strawberries are self pollinated.

Pollination occurs by the action of wind shaking the flower stem, or through native insects and honey bees. The latter is particularly true when bee colonies are located in the fields. Two colonies per ha (one per acre) are recommended. Insecticide sprays are toxic to bees. They should be applied late in the evening when the bees are less active and only when harmful insect populations exist.

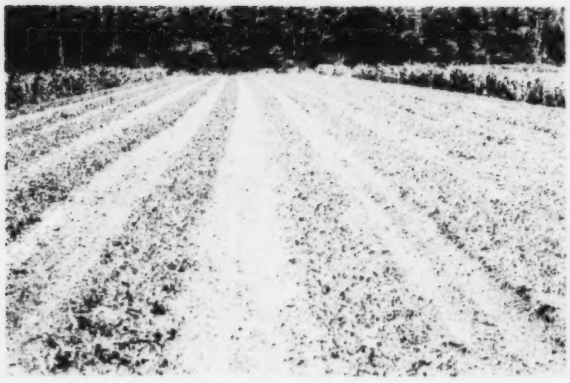
Renovation

Renovation is the management process of regenerating a strawberry planting of June bearers after harvest to keep the planting for an additional cropping year.

The cost of renovation is much less than establishing a new planting. Some growers keep a field in production for three, four or even more years.

Renovation is most successful if the plants are vigorous. Renovation is not used on plantings in the establishment year or on day neutrals.

Once the last picking is over, fields of June bearers should be renovated immediately to attain maximum regrowth in the short fall season. A week's delay may well mean a greatly reduced crop the following year.



Above: Renovated strawberry rows.

Below: U-Pick harvesting.

Strawberry plants tend to enter a stage of low activity toward the end of harvest. Renovation stimulates renewed growth and eliminates weak plants which compete for fertilizer, moisture and light.

How to Renovate

1. After the last picking, apply at least 56 kg/ha (50 lb./acre) of each macronutrient (nitrogen, phosphorus and potassium). This can be done by applying 560 kg/ha (500 lb./acre) of 10-10-10 or 336 kg/ha (300 lb./acre) of 17-17-17 directly over the rows. This could be followed by a 28 kg/ha (25 lb./acre) application of actual nitrogen in mid August. Higher levels of nitrogen may be required on lighter soils that have been exposed to nutrient leaching by excessive rainfall or supplemental irrigation.
2. Mow the tops of the plants to remove old leaves without cutting the new expanding growth. This usually occurs at a height of 2.5 to 5 cm (1 to 2 in.) above the crowns.

   Some growers have observed negative effects from mowing. This can be caused by an unusually long harvest period, which leaves less time for the development of a new, full-foliage canopy, or by mowing too close to the crowns, especially during abnormally hot weather.

   One advantage of mowing is the development of a younger, more efficient leaf canopy. This rejuvenated canopy is more effective for "recharging" the plant energy systems of fruit formation and the over wintering food reserve buildup. Mowing also offers disease and insect control benefits, especially if the old leaves are removed from the row.
3. Use a coulter on either side of the row, followed by raking to move unrooted and weakly-rooted plants into the aisle. This practice prevents plants from encroaching on the aisleway. Spacing of plants with mature crowns should be 15 to 23 cm (6 to 9 in.) apart in the matted row.
4. Applying recommended herbicides at renovation as an overall or banded spray can slow down the regeneration of the strawberry plant. Some hand weeding or herbicide spot treatment may be preferred to minimize plant stress.
5. Irrigate thoroughly and repeat as necessary to maintain sufficient moisture for vigorous growth. Apply nitrogen in early to mid August. Apply a postemergent herbicide as required. Mulch for winter protection in mid to late October.

U-Pick Harvesting

Right: Farm signs should display a neat simple message.

Far right: Information update sign.

Below: Strawberry fruit ready for harvest.

On the Prairies, most strawberries are harvested on a U-Pick basis. This method eliminates the need for harvesting, picking staff, containers, handling and grading facilities, and storing or shipping equipment.

A U-Pick operation requires high quality berries and fields that are neat, high yielding and free from weeds, diseases and insects.

Essential requirements for a successful U-Pick operation are:

- a location near an urban center, with an all weather road so customers can come to the picking location with ease
- adequate and easily accessible parking
- a way of advertising the location and the exact picking times. (One good idea is personalized business cards with maps showing the farm location.)
- excellent signage
- good telephone service - a party line is not adequate

Drawing Customers

A satisfied customer is the most effective advertisement for a U-Pick operation. Good picking, fast checkout, fair pricing and friendly staff all contribute to good customer relations.

Attractive, legible U-Pick signs are important to create a good first impression. Some provincial prairie grower associations offer U-Pick signs for their members at a reasonable cost.

Customers will be discouraged by line-ups and poor picking conditions, or if they are turned away because of poor crop information or lack of crop.

As competition for customers increases, growers should develop a positive farm identity that is distinguishable from other U-Pick operations. Today's customers patronize U-Pick farms with fresh, quality product, friendly staff and a positive country image that provides a desirable experience. All of these qualities must be promoted in advertising and customer dealings. Growers attempting to base their reputations on lower prices will usually meet with poor economic returns in the long run. Service and quality are the two by-words of today's successful strawberry grower.

Liability

Take steps to ensure the U-Pick operation is protected from liability:

- Ensure that insurance policies adequately cover U-Pick operations.
- Fence dugout areas and post signs warning of potential hazards.
- Store equipment and pesticides in a safe location and in a safe manner.
- Exercise extreme caution when applying pesticides on crops prior to harvest.
- Always follow recommended application rates and days to harvest. Many customers and young children may be sampling unwashed fruit in the field.

Time to Pick

Yields are highest when ripe berries are harvested, so pickers should be encouraged to select fully ripened fruit. Ripe berries weigh more and are larger. In fact, there is a 76%

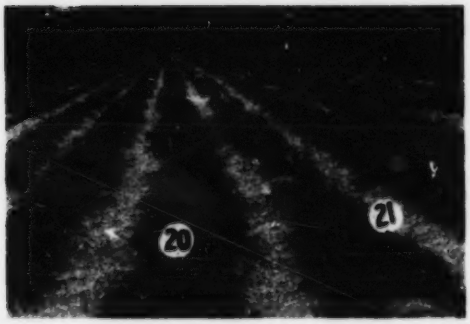
Right: An efficient checkout stand.

Below: Row signs help control customers and ensure efficient picking.

Below right: Farm rules well - posted ensure efficient picking and customer flow.

increase in berry size from the white to the fully red stage.

Customers should be invited to pick only when there are adequate numbers of ripe berries on the plants. Weather conditions determine the rate of fruit development and thus the number of times a field should be picked each week. In hot weather, fruit ripens faster and picking every two days may be required. When cool weather delays ripening, picking every three days will be sufficient.



The Picking Operation

Customers come to the service booth for directions to picking locations and to have their containers weighed or marked. Number the strawberry rows in the field to be harvested.

Field supervisors should be instructed to help customers find the assigned row and ensure they pick only in that area. A rule of thumb for staffing is to have one field supervisor for approximately 40 U-Pick customers.

The scale and check-in booth should provide protection from sun and rain for equipment, staff and customers. The booth must also be adequately staffed to avoid customer line-ups. Post current price information in a prominent location to speed up customer check-out.

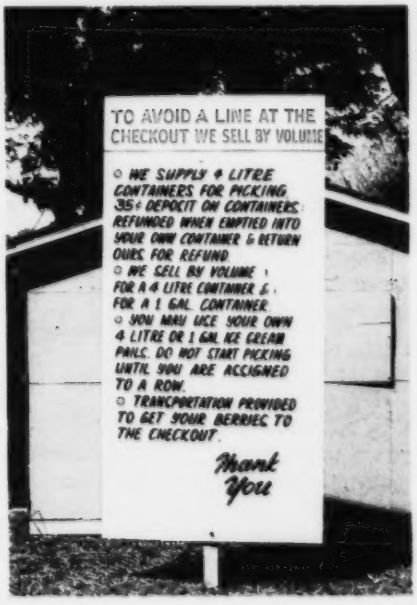
Many berries are sold by volume. A 4 L (0.88 gal.) basket has become the standard container size. Customers may also bring their own 4 L (0.88 gal.) ice-cream pails. Remember, berries should never be picked into one container and then dumped into another. This process causes unnecessary bruising of the tender fruit and

creates delays at the checkout. Most U-Pick fruit travels home in hot car trunks. Under these conditions, fruit freshness and quality are preserved better in shallow, waxed cardboard containers. Growers can use these containers to promote their farms. Some offer refunds if the containers are recycled.

Sales Etiquette

Staff who meet the customers should be friendly, helpful and patient. Fair and friendly treatment promotes goodwill and is the best way of getting customers to return. Today's U-Pick customer not only expects service but demands it.

Sale of Picked Berries


TO AVOID A LINE AT THE CHECKOUT WE SELL BY VOLUME
WE SUPPLY 4 LITRE CONTAINERS FOR PICKING 35¢ DEPOSIT ON CONTAINERS REFUNDED WHEN EMPTIED INTO YOUR OWN CONTAINER & RETURN OURS FOR REFUND
WE SELL BY VOLUME FOR A 4 LITRE CONTAINER & FOR A 1 GAL. CONTAINER
YOU MAY USE YOUR OWN 4 LITRE OR 1 GAL ICE CREAM PAILS. DO NOT START PICKING UNTIL YOU ARE ASSIGNED TO A ROW.
TRANSPORTATION PROVIDED TO GET YOUR BERRIES TO THE CHECKOUT.
Thank You

When berries are picked for sale, provide a properly graded product. Pickers should be trained to harvest product that will meet all grade requirements. Cooling the product quickly to 1° to 2°C (34° to 36°F) is important for maximum shelf life.

Amenities

Clean washroom or toilet facilities must be available at all times. Where outhouses are used, provide hand washing stands nearby. Locate these facilities at a site that is well away from the picking area but also convenient for customers. Many people regard a pick-

U-Pick Harvesting

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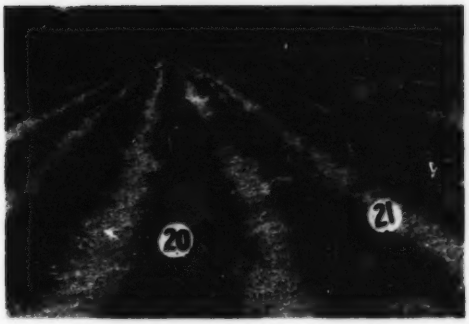


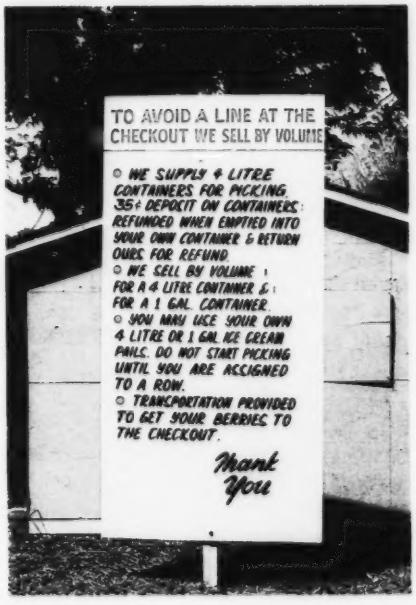
The Picking Operation

Customers come to the service booth for directions to picking locations and to have their containers weighed or marked. Number the strawberry rows in the field to be harvested.

Field supervisors should be instructed to help customers find the assigned row and ensure they pick only in that area. A rule of thumb for staffing is to have one field supervisor for approximately 40 U-Pick customers.

The scale and check-in booth should provide protection from sun and rain for equipment, staff and customers. The booth must also be adequately staffed to avoid customer line-ups. Post current price information in a prominent location to speed up customer check-out.

Many berries are sold by volume. A 4 L (0.88 gal.) basket has become the standard container size. Customers may also bring their own 4 L (0.88 gal.) ice-cream pails. Remember, berries should never be picked into one container and then dumped into another. This process causes unnecessary bruising of the tender fruit and


TO AVOID A LINE AT THE CHECKOUT WE SELL BY VOLUME
WE SUPPLY 4 LITRE CONTAINERS FOR PICKING. 35¢ DEPOSIT ON CONTAINERS REFUNDED WHEN EMPTIED INTO YOUR OWN CONTAINER & RETURN OURS FOR REFUND
WE SELL BY VOLUME : FOR A 4 LITRE CONTAINER & : FOR A 1 GAL. CONTAINER
YOU MAY USE YOUR OWN 4 LITRE OR 1 GAL ICE CREAM PAILS. DO NOT START PICKING UNTIL YOU ARE ACCIGNED TO A ROW.
TRANSPORTATION PROVIDED TO GET YOUR BERRIES TO THE CHECKOUT.
Thank You

creates delays at the checkout. Most U-Pick fruit travels home in hot car trunks. Under these conditions, fruit freshness and quality are preserved better in shallow, waxed cardboard containers. Growers can use these containers to promote their farms. Some offer refunds if the containers are recycled.

Sales Etiquette

Staff who meet the customers should be friendly, helpful and patient. Fair and friendly treatment promotes goodwill and is the best way of getting customers to return. Today's U-Pick customer not only expects service but demands it.

Sale of Picked Berries

When berries are picked for sale, provide a properly graded product. Pickers should be trained to harvest product that will meet all grade requirements. Cooling the product quickly to 1° to 2°C (34° to 36°F) is important for maximum shelf life.

Amenities

Clean washroom or toilet facilities must be available at all times. Where outhouses are used, provide hand washing stands nearby. Locate these facilities at a site that is well away from the picking area but also convenient for customers. Many people regard a pick-

your-own trip as a fun family outing that may include a picnic. It is worthwhile to provide a shady area with some tables, as well as conveniences such as a soft drink dispensing machine. Play areas, sand boxes and swings for children could also be added. Special customer services such as fishing holes, hiking trails, petting zoos and alternative crops can all enhance your farm's profile. To sustain continued growth, U-Pick farms will have to provide more than fresh, high quality fruit for their customers.

Equipment for Strawberry Production

Equipment should be carefully selected for the strawberry enterprise. Consult other growers for advice on performance and general characteristics suited to the needs of the specific operation. Factors to consider include equipment flexibility, type of production and long term enterprise goals.

Tractors

Select a tractor, perhaps a small four-wheel drive unit, that is capable of powering a rototiller. Too large a unit will contribute to soil compaction and will be inefficient to maneuver.

Equipment Required

- planter
- sprayer capable of delivering 455 L/ha (100 gal./acre) and at least 1379 kPa (200 psi) pressure
- rototiller
- straw spreader
- irrigation equipment
- irrigation pipe trailer
- frost alarm system
- fertilizer spreader
- soil subsoiler (optional)

Pesticide Safety and Management

Consumer consciousness of pesticide use in farming is a major grower concern. Surveys have shown that as much as 80% of the population is concerned about pesticide safety on the food products they buy. U-Pick operations can imply freshness, quality and consumer-buying confidence when consumers can meet growers and be assured that their pesticide practices are safe.

Growers will be faced with increased public pressure to control and minimize the use of pesticides in crop production. Alternative management techniques will be necessary to strengthen consumer confidence. Growers should also help dispel misinformation about pesticide residues. For example, it is estimated that the average American citizen is exposed to 46 micrograms of potentially carcinogenic pesticide residues in food and water daily, while a single cup of coffee contains about 500 micrograms of potential carcinogens.

Consider these factors when selecting pesticides for crop management:

Toxicity of the Chemicals

Chemicals with high LD 50 ratings are less hazardous to the grower and the environment. For example malathion, which has a LD 50 rating of 1200, is not as toxic as guthion, which has a LD 50 rating of 7. *Use only chemicals registered for use on strawberries* and follow label specifications for rates, days to harvest waiting periods and other conditions. Failure to follow this basic rule of pesticide safety exposes the grower and industry to undue liability and increases the risk to the consumer.

Proper Safety Equipment

Protective devices such as approved gloves, a recommended respirator and approved clothing should be used when handling pesticides. Insticides can enter the body through the mouth (orally), through the skin (dermally), or through the lungs (respiratory system).

Poisoning

Know what to do in the event of a spill or accidental poisoning. Review procedures on the container label before handling a pesticide.

Safe storage and disposal of containers and unused material is important to protect children of U-Pick customers from accidental exposure.

Chemical Application

Pesticide application through the irrigation system is not recommended because coverage is not efficient. As well, there is a danger of water supply contamination because irrigation water containing pesticide can flow back into the water source if mainline pressure drops suddenly. Contamination by back siphoning can be avoided by using a reduced pressure back-flow preventer. This device is installed in the supply line at a point well ahead of the material injection point. Similar precautions to control back-flows should be observed when filling sprayers from lakes, rivers or streams.

NOTE: Before installing this unit, consult the water authorities regarding local regulations.

Observe the waiting period specified on the label before entering treated fields. If the waiting period is not observed, chemicals on the foliage can be absorbed through workers' skin or lungs.

Spraying Effectiveness

Several factors influence the effectiveness of pesticide application. These include correct diagnosis of the problem, appropriate spray intervals, resistance of the pest and weather conditions. A water pH of 8 or more can also affect the efficiency of certain pesticides.

High spray pressure is essential for full coverage of the large foliage area of a strawberry row. Pesticides must be applied in at least 1123 L/ha (100 gal./acre) of water at a pressure of 1379 kPa (200 psi). Field sprayers with low volume and pressure capability are not suitable for spraying insecticides and fungicides on strawberry crops.

For greater coverage, use a chain ruffler rather than a solid bar. Nozzles should be set to a point slightly forward so material is applied immediately behind rather than in front of the chain. This nozzle position will provide increased coverage of the upper leaf surface and twice the coverage of the underside.

Strawberry Problems

The ability to recognize and correct production problems early is essential for a successful strawberry operation. Shortcuts in preparing and maintaining a strawberry field will often result in serious pest problems later in the production cycle. Conduct frequent field inspections, perhaps daily during the early portion of the production cycle. Weak stands of strawberries are more prone to insect and disease attack and therefore should be monitored more frequently.

Problem Identification

Knowing the habits and damage characteristics of a disease or insect is the key to field problem diagnosis. For example, wilting of new leaves in the crown is a tell-tale sign early cutworm damage. Quick action at this stage can minimize damage to the planting.

However, in some cases, corrective action must be taken before obvious signs of injury appear. For example, the tarnished plant bug can cause serious damage while the plant is still in the blossom stage, but injury does not become obvious until after the insect has left the blossom. Therefore, it is important to monitor the tarnished plant bug population with traps or frequent field inspections during the blossom stage. Tarnished plant bug levels of one to two nymphs per flower or higher warrants an insect control measure.

Physiological Problems

Strawberry plants are affected by a number of problems that are not caused by insects or disease. These are physiological in nature.

Tip Burn of Leaves

This condition is the result of a temporary calcium shortage. It occurs in young strawberry plants during periods with hot days and cool nights or after a frost to young unfolding leaves. The symptoms are slightly malformed leaves with dry leaf margins. This condition is usually not considered serious. Application of calcium chloride in a water solution at 1.12 kg/1123 L/ha (1 lb./100 gals./acre) as a foliar spray is helpful.

Yellowing or Chlorosis

Red Coat and certain other cultivars appear to be more sensitive to this condition, which produces a fading or yellowing of foliage (see color section). Chlorosis development is influenced by genetic makeup of the cultivar, soil alkalinity or salinity, topography and soil aeration. Temporary yellowing can occur on waterlogged soils after long periods of irrigation for frost control or excessive rainfall. Yellow strips of "mother plants" frequently occur during growth early in the season. These plants generally have suffered winter injury to the root system. In some severe cases the yellowing can be corrected by incorporating an iron chelate into the soil at the rate of 14.3 kg/ha (13 lb./acre) of actual iron.

Wind Damage to Plants and Fruit

This condition can result from poorly sheltered strawberry plantings. Exposure to strong winds and wind borne soil particles will cause "tar spots" on the leaves and stems. This damage is caused by a chemical change in the cell contents when they are exposed to air. The reaction is similar to exposing the surface of a sliced apple to air. Wind damage can reduce plant vigor as well as quality and shelf life of fruit from young plantings.

Sunscald of Fruit

When fruit receives too much exposure to the sun, the skin can break down or soften, causing sunscald (see color section). The symptom is a discoloration of the fruit surface ranging from pink to off-grey. Fruit not protected by a good foliage canopy is prone to this condition. Berries on the south or west sides of rows are especially vulnerable to damage.

Stunting and Small Leaf Development

Winter injury is often the cause if these symptoms are exhibited over the whole field. Repeated freezing and thawing or low snowfall often precede this condition. The problem can be verified by cutting the plant crown vertically and examining the tissue for brown discoloured areas. Plantings that incur winter injury early in their life cycle rarely recover. Early plow down of the planting may have to be considered.

2,4-D Damaged Fruit

Deformed fruit showing "lines" or "folds" along the berries can be caused by 2,4-D drift

at the time of fruit bud initiation. Even a minimal amount of herbicide drift can result in abnormal fruit. The period of sensitivity for June bearers is usually late fall. Day neutrals are susceptible any time during active plant growth.

Disease and Insect Control

Pesticides help control insects and diseases but should only be used when necessary to prevent a loss of income. Adopt an integrated pest management approach that combines monitoring of pest populations with use of injury threshold levels. The timing of application is also important to prevent economic loss for the current crop and for the life of the planting.

For pesticide recommendations, consult the annual guides published by your provincial department of agriculture. Also pay careful attention to the information on the product label, including safety precautions, mixing instructions, application rates and days-to-harvest waiting periods.

Insect cycles and populations are affected by weather. For example, normal hatch times can be shifted earlier in a mild spring. If above-normal temperatures prevail during the production cycle, the crop may have to be monitored and sprayed more frequently.

Insect control begins with sanitation. Isolating new and old fields reduces the risk of insect migration to new crops. Weeds often harbour insects that attack strawberries during flowering and fruiting periods.

The purchase of certified strawberry plants is a significant part of a disease control program. The plants are as disease-free as possible.

In the production season, fields should be examined for off-type plants. They should be pulled, examined and removed from the field. If the problem cannot be identified, call the local authority for assistance.

Strawberry Insects

NOTE: Portions of this section are taken from a paper authored by Dr. N. J. Holliday, Department of Entomology, University of Manitoba, titled "Integrated Pest Implications for Manitoba Strawberry Growers - 1988".

Insects that Attack Leaves

Strawberry Leaf Roller *Amcylis comptana fragaziae* (Walsh & Riley)

Young larva of this moth feed on either side of the leaf. Often, two adjacent leaflets are tied together or a single leaf is rolled. Damage is usually more common on new plantings late in the growing season.

Leaf rollers are very susceptible to attack by several parasites and populations are usually kept at low levels. Insecticide application is usually not necessary. Occasionally, high populations coincide with fruiting and can cause severe damage.

Aphids

Aphids are small, soft bodied and usually green or yellow in colour (see color section). They seldom cause direct injury, but some transmit virus diseases. Several kinds of aphids feed on the undersides of leaves or stems.

Cyclamen Mite *Steneotarsonemus pallidus* (Banks)

Mites are not considered true insects. This mite is small and scarcely visible to the naked eye. It is mainly a pest on greenhouse plants, but has caused serious losses to strawberry plantings.

The cyclamen mite feeds on the young unfolding leaf in the crown of the plant. Damaged leaves are stunted, crinkled and

malformed when they emerge (see color section). Later the mite feeds on blossoms causing distorted fruit to form.

Use plants free of mites to establish a new planting. Once present, mites are hard to control. High populations can develop during hot, dry weather. Densities of 45 to 65 mites per leaf can result in a 33% yield reduction. (Alford 1972).

Maintaining plant vigor and avoiding water stress is important in enabling plants to tolerate cyclamen mite populations.

Cyclamen mites are not very mobile but are often transmitted to new plantings on nursery stock or equipment. Physical field separation and prevention of accidental transportation of plant debris from infested stands are important.

Two Spotted Mite *Tetranychus unticae* (Koch)

The two spotted mite is an injurious pest that feeds by sucking out the contents of individual cells. Population densities of 1 to 5 mites per leaf result in a mottling of leaves. The mottling changes to general bronzing at densities of 20 mites per leaf (Alford 1976). At higher densities leaves become covered in webbing and dry up. Severely attacked plants lose vigor and die.

Mites feeding at low densities may reduce fruit production even when there is no visible injury. A count of five mites per leaf before July 30 is frequently used as an economic threshold for perennial strawberry plantings. (Schaeffer 1980).

To monitor this pest, examine the undersides of the leaves. The adults are about 0.4 mm long and leave tell-tale signs of webbing. Expect higher mite populations on plants that have undergone some form of stress.

Use arcaricides rather than general insecticides to provide some protection to the numerous natural predators of spider mites. Spider mite predators tend to become established as a strawberry planting matures, provided the natural buildup is not prevented by use of insecticides.

Pests that Attack the Blossoms of Fruit

Tarnished plant bug *Lygus limeolaris* (Palisotde Beauvois)

The tarnished plant bug is one of the most serious and widespread strawberry pests. They are especially destructive on day neutrals grown in the Prairie area. The insect is small and green in the early nymph stage. Nymphs feed on the blossoms which subsequently develop into nubbins or deformed fruit.

Adults are flat, level and oval in shape, and 0.6 cm (1/4 in.) with mottled brown or brown coloration (see color section). The adults fly when disturbed. Adults overwinter in plant debris and lay their eggs on the plant stems in the spring. The young hatch, then feed on the developing blossoms and fruit.

Tarnished plant bugs also feed on the developing fruit. This causes "catfaced" berries (see color section). When fruiting is completed adult bugs leave. In most June bearing plantings on the Prairies, bugs migrate into fields in the fall or spring and then leave in June or July. Day neutral plants may sustain populations continuously because of the different fruiting habit.

The insect forages on a wide variety of flowers that bloom at different times, including alfalfa. If alfalfa located near strawberry fields is cut in July, high populations of this insect may move to the strawberry plants.

Tarnished plant bugs have also been observed feeding on sunflower windbreaks. This may be discouraged by cutting off the flower heads at an early stage of their development.

Tarnished plant bugs can damage as much as 85% of the fruit. Schaeffers in 1979 found that one nymph per inflorescence resulted in 20 to 30% of the fruit being injured. This reduced the average berry weight by 18%. The economic threshold is less than one nymph per inflorescence.

For control in day neutrals, use chemicals that have some carryover effect prior to fruiting. This can be followed by a spray with a short days-to-harvest interval material applied two to three times per week throughout the fruiting period.

Strawberry Bud Weevil *Anthonomus signatus* [Say].

This dark reddish brown weevil is about 3 mm (1/10 in.) long with a head that has a slender, curved snout about half as long as the body (see color section). This insect is known as "the strawberry clipper" or simply "clipper" because of its habit of clipping buds.

The adult beetles leave their winter quarters in fence rows and woodlands about the time the first strawberry blooms appear. Eggs are deposited in the blossom as it opens or in buds that are nearly matured. The adult then cuts the stem of the bud and it falls to the ground or hangs by a thread (see color section). In one week, the eggs hatch into white, legless grubs. Larva develop inside the bud and reach maturity in three to four weeks.

The new generation of adults appear in early summer and are active in late June or July. No damage occurs at that time. After feeding on the pollen of various flowers for a short time, they seek hibernating sites until the next spring. There is one generation each year.

Early blooming cultivars are more prone to "clipper" damage. Monitor fields frequently in May when flower buds begin to develop. A rough economic injury level appears to be two clipped buds per meter (yard) of row (Schaefer 1980). Control measures should occur before this level is reached. Injury is most likely to occur where strawberries are grown adjacent to woodlands or other suitable hibernating areas.

Cultural control includes minimizing the amount of trash in and around fields during mid to late summer and separating new plantings from old crops with high clipper populations. Vigorous tillage of the old beds immediately following the final harvest will minimize movement of the clipper to the new plantation. Clippers are vulnerable to tillage at this time because they are in the immobile pupae stage in the soil.

Strawberry Root Weevil *Otiorhynchus ovatus* [L.]

A number of weevil species attack strawberry plants. In the immature stage, these weevils are legless, live in the soil and feed on the fibrous roots of strawberries or tunnel into the crown. The adult weevils are brownish or blackish and 5 to 10 mm (0.2 to 0.4 in.) long. Adults feed on the edges of leaves, causing them to appear ragged or notched. In contrast, the feeding damage of caterpillars tends to consist of roundish extensive holes.

Larva or adults overwinter in trash. Populations of strawberry root weevils tend to increase as the planting ages and can severely stunt or kill plants.

Strawberry root weevils may be controlled with insecticides. Growers can also use cultural controls, such as crop rotation and isolating fields from wild plants that harbour weevils. Tillage is not very effective in destroying weevils.

Strawberry root weevils are unable to fly so damage is restricted to small areas. Watch for leaf damage and examine the crowns of weak plants for evidence of root weevil injury. Monitoring on a continuing basis should not be necessary.

Cutworms

These voracious caterpillars may feed on plants at any time during the growing season. Young plants are occasionally cut off at the soil surface by cutworms. They feed on the leaves of older plants but cause insignificant damage unless they are very abundant.

The greatest damage results when cutworms feed on ripe fruit, making large holes in the berries. These holes are larger than those made by leaf rollers. Each cutworm feeds on a number of berries in a localized area.

The stout caterpillars are nearly 25 to 37 mm (1 to 1.5 in.) long and are striped, mottled or dingy grey. They feed at night and are seldom observed in the fields. During the day they burrow into the soil or hide beneath plant debris. Unlike slugs, they do not leave slime trails.

Most cutworms that attack strawberry plants overwinter as partially grown caterpillers in the field. They become active early in the spring. As they reach full growth, they pupate in the soil. Brownish or greyish moths emerge and are active only at night.

Economic thresholds for cutworms in strawberries have not been established. Cutworms that attack the crowns or several fruiting stems are much more damaging than those that eat leaves. The economic threshold for leaf feeding species will be much higher than those affecting fruiting structures or plant survival.

The cutworm *Amphipoea interoceanica* (Smith) was recently identified. Eggs of this species are laid on dead strawberry leaves in August and hatch in early May. Young larva feed on leaf stalks. Later they bore into the crowns and kill the plants.

Plants are first attacked in the second year. By the fifth year, the entire planting may be lost. Second year stands may show patchy

infestations which become more severe as the stand ages (see color section). This general decline in vigor is often mistaken as winter injury.

Adults of this species seem to have a short flight range. Females lay eggs in an established field, where the larvae probably feed. Females seldom leave the field unless the crop can no longer serve as pasture.

These characteristics make the strawberry cutworm easier to control because an insecticide application will kill the population and others will not move into the area. For chemical control, apply only those compounds specifically recommended for cutworms.

Because many species overwinter in fields as eggs or partly grown larvae, tillage after the final harvest can help control cutworm populations.

Slugs

Slugs have damaged strawberries in Manitoba but do not appear to be active in other areas of the Prairies. Although the loss of fruit from slug feeding is usually not significant, customers are repelled by the presence of slugs on the fruit they are picking or by the slime they leave behind.

The native marsh slug (*Deroceras laeve* [Muller]), overwinters as an adult in trash and leaf litter in hedge rows and windbreaks. Most eggs are laid in June and July. By fall the slugs are full grown and about 15 mm (0.6 in.) long.

For most of the year, slugs feed on fungi and decaying vegetation in the trash (see color section). However, slugs will feed on strawberries when they are present and particularly if field conditions are wet.

Slugs are difficult to monitor because they are usually in the soil and inactive. To estimate populations, search 0.1 m^2 (1/sq.ft.) areas of straw mulch and trash, digging down to the compacted soil. Watch for the presence of slug eggs or slugs. Badly infested fields may contain up to 50 slugs/m^2 (10/sq. ft.). These populations will only pose a severe problem if field conditions are wet at harvest.

Slug populations can build up and cause severe losses over the life of the strawberry planting. Prevention of population buildup rather than treatment of a heavy infestation is a better objective.

When damage occurs early in the fruiting season, apply chemical controls or till headlands and inter-row areas. The use of slug baits has met with some success. Banding sprays over the rows during the hours of slug activity can also be effective. Cultural control by slug habitat management is probably the most effective measure. Limiting excessive straw use and adopting vigorous tilling at renovation will also help.

Slugs seldom move far by themselves but are often transported with tillage equipment or soil. Precautions should be taken to prevent subsequent introduction in this way.

Strawberry Diseases

Diseases Attacking the Leaf

Strawberry fruit fungal diseases are usually not a problem during an average dry prairie summer. Prairie strawberry growers do not regard leaf diseases as a serious concern since they do not appear until after picking.

After renovation, a healthy foliage canopy must be maintained for fruit bud set and storage of winter food reserves. Risk of strawberry leaf and fruit diseases is reduced with renovation and removal of tops from the field. Tops are an inoculum source that may reinfect foliage the following year under suitable conditions.

Leaf Spot (*Mycosphaerella fragariae* [Tul.] Lindau)

This disease first appears on leaves as purplish spots that resemble leaf scorch (see color section). Later these spots enlarge to a diameter of 3 to 6 mm (0.13 to 0.25 in.). The centers become grey or white with reddish to purplish borders. Leaf petioles or stalks, stolons, runners and, to some extent, calyxes (caps or hulls) may be attacked.

Plants and leaves are mostly susceptible early in the growing season and in late summer, especially where growth is very succulent. The leaf spot fungus may also attack the fruit and cause black seed.

Spores of the fungus form on the spots and are spread by rain, hands, tools and clothing when plants are wet. Some cultivars are more susceptible to leaf spotting than others. Timely fungicide sprays are an effective method of control.

Powdery Mildew (*Sphaerotheca macularis*)

Powdery mildew affects all above ground parts of the strawberry plant. Leaves, flower calyxes and fruit all support mildew growth. Infected leaves curl upward, become purplish on the underside and, in severe instances, develop badly burned areas at the margin. A white, powdery fungus growth may be seen on the underside of severely affected leaves. Powdery mildew develops in the spring and fall.

Infection begins in the spring soon after plant growth starts. The spread is gradual and may not be noticed until most plants in the field are infected. If a severe outbreak occurs before picking, the crop may be greatly reduced. Symptoms are most noticeable on warm, dry days.

Dense shelterbelt plantings that restrict good air flow will favour the spread of this disease. Timely fungicide sprays are an effective method of control.

Diseases Attacking the Fruit

By far the most important strawberry diseases are the fruit rots caused by several fungi. They are capable of destroying a large percentage of the fruit. Picking and packing are also more costly when these diseases are present in the field. Losses vary with time and location, as well as weather conditions from first bloom through harvest.

Grey Mold *Botrytis cinerea*

Grey mold is very common and often causes serious losses in strawberries. Customers usually complain of off-flavored fruit if berries infected with grey mold are eaten. This disease affects blossoms and blossom stalks of green or ripe fruit. Infection usually starts in the blossom and may destroy the entire blossom stalk. The blossom infection can enter a dormant period in the calyx or hull, then become reactivated to cause fruit rot.

The rot is soft and light brown in color. The fungus may spread to other blossoms and berries through direct contact, or by spores that are blown or splashed. A fine grey powdery growth develops and infects blossoms, fruit stalks, fruit and other plant parts (see color section). Fruit rot and grey mold may appear on the picked fruit for one or two days.

Grey mold is favoured by shade or dense foliage in the bed and extended periods of excessive moisture. The likelihood of infection is increased by cool spring and summer temperatures and high humidity from frost control techniques, general irrigation and natural rainfall. Black plastic mulch dries off faster than straw and therefore slows mold growth. Fruit rot can also be favoured by factors that produce soft fruit, such as high applications of nitrogen during fruiting.

Apply protective fungicides at bloom and continue until harvest if cool wet conditions prevail.

Other Fruit Rots

Several minor rots can attack fruit and cause significant damage to certain day neutral cultivars under ideal environmental conditions.

Leather rot (*Phytophthora cactorum*) gives fruit a dull or lifeless appearance with color ranging from bleached to purple to nearly normal. Fruit is discolored internally and externally and usually has a dry leather appearance (see color section).

A second fruit rot is caused by anthracnose fungi (*Gloeosporium spp.*). Unripe to ripe fruit develops compact, sunken areas - tan to dark brown in colour - which become circular, water-soaked lesions.

Tan brown rot caused by *Hainesia lythri* is commonly found in September on fruit of day neutral strawberries. The symptoms are small, tan, slightly sunken spots on the fruit. As the rot progresses into the berry the decayed tissue is replaced with fungal mycelium which becomes dry and spongy. Hainesia attacks a wide range of weed hosts which may occur in the vicinity of strawberry plants and serve as a source of infection. The fungus can overwinter on infected plant debris. Control by cultural practices such as mulching, weed control and removal of plant debris.

Diseases Attacking the Root

Black Root Rot

This disease is caused by a number of different fungi including Pythium, Fusarium and Verticillium which are common in most soils. Young, healthy roots are white or clear in appearance. With age, the roots become brownish or darker on the surface and have a yellowish living core. When infected by root rots, main roots appear dark and patchy, then turn black. The entire root decays, including the core. Feeder roots are killed quickly.

Root rot fungi are favoured by winter injury, poor drainage and acid or alkaline soils. Plants affected by root rot have reduced vigor and may die. The disease may prevent newly set plants from becoming established, and may kill established plants before or during harvest. The time required to kill the plant depends on factors such as soils, temperature, moisture and growing practices.

Storage Mold

This mold can kill new plants and is caused by several organisms. Do not plant mold infected plants. Dipping plants prior to planting in a recommended fungicide bath is a good preventative measure.

Verticillium wilt *Verticillum albo-atrum* (Reinke Berth)

Although not common, the disease tends to be prevalent and destructive in semi-arid, irrigated areas. It is carried by the soil borne fungi *Verticillum albo - atrum* (Reinke Berth), which may spread from tomatoes, potatoes, alfalfa and other annual and perennial crops. This fungus persists in the soil for up to seven years. Symptoms include browning at leaf margins and between veins, followed by eventual collapse. Inner leaves are stunted but tend to remain green and turgid until the plants die. Control is obtained by soil fumigation with methyl bromide. Losses can also be reduced by planting cultivars with moderate to high resistance to this disease.

Viruses

Viruses can be identified by the symptoms of plants in the field or by use of indicator plants. Virus diseases are usually named after the symptoms they produce. For example, "Witches Broom" produces a stunted, plant with many small leaves originating from one point, creating a "broom" effect.

Virus diseases are spread by insects, chiefly aphids and leaf hoppers. Once a plant is infected, it does not recover. All plants attached to it by runners also become infected through the transfer of virus particles in the plant sap.

To reduce the spread of virus diseases, use certified plants, followed by a full spray program. As well, remove any off-type plants from the field. Growers located near large native stands of wild strawberries must be more vigilant to avoid virus contamination.

Weed Control

An effective weed control program combines initial identification of the weeds with appropriate cultural and chemical control procedures. Consult your provincial weed guide for recommended herbicides, rates of application and spraying procedures.

Precaution - Phytotoxicity

Note: The following is an excerpt from the "Guide To Chemical Control For Strawberry Production In Atlantic Canada 1989, Publication 1012".

Herbicides must be applied at the recommended rates to avoid injury. Cultivars vary in their sensitivity to herbicides at certain stages of the plant growth cycle. Application of a trial strip in the field before overall treatment is recommended when specific cultivar recommendations are not available. A chance of phytotoxicity from excessive rates or the stage of growth of the plants is much greater with herbicides than with most other pesticides.

Crop injury from use of herbicides is not uncommon, particularly on light soils. Post emergent application injury can result from use of a high rate on light soils, improper timing of sprays, improperly calibrated sprayers, sensitive cultivars and weak plants growing under unfavorable conditions. Injury can take the form of temporary chlorosis or yellow "haloing" of margins around the leaf edge. This is followed by complete chlorosis and finally death of the plant.

Newly planted and actively runnering strawberries are especially sensitive to herbicides. Crop tolerance increases in late summer and fall. Light soils (sandy soils) require lower rates than heavy soils for comparable levels of weed control. Strawberries growing on soils low in organic matter are especially prone to herbicide injury. Lower rates of herbicides should be used on fields containing less than 2% organic matter. Do not exceed maximum recommended annual application rates or overlap areas during application. The use of a flat fan type nozzle is recommended.

Straw Fumigation

Weed seeds tend to be killed in straw when it is treated with ammonia. This reduces weed seed introductions from straw used as mulch. Fumigated straw is also somewhat less rigid than nonfumigated straw.

Mulching with fumigated straw is an excellent way to reduce weed problems in production of day neutral strawberries where herbicide options are limited due to days-to-harvest restrictions.

To fumigate, straw is tarped with plastic and ammonia gas is injected at the rate of 2% of the straw's dry weight. For example, a 27 kg (60 lb.) bale of wheat straw with 20% moisture has a dry weight of 27 x 0.8 = 22 kg (48 lb.). Therefore, the amount of ammonia to inject into the bale would be 22 x 0.02 = 0.44 kg (1 lb.) of ammonia gas. This calculates to 20 kg/t (42 lb./ton) of straw.

Preparing the Land

To ensure optimum weed control throughout the entire life of the strawberry field, the crop must be established in soil that is as weed free as possible.

In fields with perennial weeds such as quackgrass and thistle, do not cultivate in the fall prior to a fallow year. Short term cultivation tends to propagate rather than control these weeds. Chemical control may be an option for late summer-fall use. In the spring, till at a shallow depth to control annual weeds. Allow perennial weeds to recover and apply herbicides as recommended.

Applying a registered preplant herbicide in the spring will reduce labor requirements for weed control in the first year.

On Newly Planted Strawberries

When preparation for a new strawberry field includes recommended summerfallow practices and use of a preplant herbicide, only the few weed seeds which germinate should be a problem after transplanting. It is important to realize that the herbicide treatments recommended in the summer after transplanting will not control perennial weeds that grow from underground root structures. Most weeds growing from seed can be controlled if a recommended herbicide is used.

After Transplanting

Cultivation will be necessary to control weeds until plants are established. Once plants are well set, herbicides can be applied two ways: as an overall spray, or as a band applied over the row combined with cultivation between the rows. The latter procedure minimizes the cost of herbicide application.

Four to Six Weeks After Transplanting

Several excellent herbicides can be applied after mother plants are well established. At this stage, care must be taken with certain pre-emergent chemicals to ensure full rooting of the mother plant and daughter plants.

Several post-emergent herbicides can also be effective when applied at the correct growth stage of weed seedlings.

In Established Beds

Applying pre-emergent herbicides in the fall, prior to mulching, will give effective control of weeds germinating in the spring. Perennial weeds should be controlled with spot application of herbicides. Registered post-emergent herbicides for broadleaf and grass control can be applied in the bearing year prior to harvest, providing the "days to harvest" are observed.

Several pre-emergent herbicides can be applied after renovation to control germinating weeds up to strawberry dormancy. However, care must be taken to ensure the planting is strong enough to withstand the potential herbicide injury.

Cost of Production

According to surveys conducted in Manitoba and Atlantic Canada, cost of strawberry production is $3705 to $5187/ha ($1500 to $2100/acre) per year for the seven year total production cycle (two fallow years, a planting year and four picking years). This includes 185 person hours/ha (75 person hours/acre) per year. Average provincial yields for established prairie growers range from 4482 to 8960 kg/ha (4000 to 8000/lb./acre) per year for the four picking years. Prices range from $1.45 to $2.60/kg ($0.66 to $1.30/lb.) for U-Pick strawberries. Break-even prices can range from $0.68 to $0.88/kg ($0.32 to $0.40/lb.) for a 5614 kg/ha (5000 lb./acre) yield.

Rate of return varies greatly depending on the management practices used in individual enterprises. Potential rate of return per dollar invested should be similar to other businesses and greater than what is available in a short term investment. Prospective growers should take the time to consult with their provincial farm management specialist to draft a budget tailored to their particular situation.

Factors that must be considered include:

- winter injury losses (0 - 100%)
- no revenue for the first three years (two fallow years and one establishment year)
- high capital cost of irrigation system
- labour availability
- market saturation potential and marketing possibilities for excess fruit in a bumper crop year
- vulnerability of short harvest season (3 to 4 weeks)
- excessive rain or heat
- hail risk
- weed, insect and diseases risks

New Developments

The most dramatic changes occurring in the small fruit U-Pick trade are those related to the market. Growers located far from large urban centers are seeing a softening of the U-Pick market demand. The new potential customer does not have the desire or the time to harvest and preserve fruit in the present U-Pick marketing format. More emphasis will have to be placed on attracting new customers by providing entertainment and a fun family outing as well as high quality, farm-fresh fruit.

Innovative and aggressive growers will survive and expand in this market. The busy family of tomorrow will be looking for fresh, good quality strawberries as well as the convenience of frozen fruit packs, jams and other processed products. The consumer will respond to a longer harvest period by purchasing fresh strawberry fruit more frequently.

The hotel, restaurant and institutional trade is a large untapped market. These customers require high quality, chilled fruit. New, well storing fruit cultivars, innovative packaging (i.e., modified atmosphere packaging), controlled environment and forcing of day neutral strawberries will be some of the ways to extend the period when fresh strawberries are available.

Today's consumers are eating 3 L (2.6 qt.) per capita as part of an improved life style. This health consciousness is expected to continue and expand in the 1990s. The modern consumer demands high quality fresh strawberries throughout the year. The challenge of today's strawberry growers is to meet most, if not all of this demand.

Further Reading

Manitoba Insect Control Guide

Available from Ag Rep Offices or Agriculture Publications, 200 Vaughan Street, Winnipeg, Manitoba, Canada R3C 1T5

Calibration for Band Spraying

– Agdex 744 – Available from Agriculture Publications, 200 Vaughan Street, Winnipeg, Manitoba, Canada R3C 1T5

Soil Testing Services in Manitoba

– Agdex 533 – Available from Agriculture Publications, 200 Vaughan Street, Winnipeg, Manitoba Canada R3C 1T5

Plant Tissue Analysis

– Agdex 533 – Available from Agriculture Publications, 200 Vaughan Street, Winnipeg, Manitoba, Canada R3C 1T5

The Morphology and Physiology of the Strawberry

G.M. Darrow, reprinted by North America Strawberry Growers' Association

Strawberry Deficiency Symptoms – A Visual and Plant Analysis Guide to Fertilization

Albert Ulrich, MAE Monstafa, W.W. Allen, Publication 409 8, $8.00 U.S. funds*, Agriculture Science Publication, a Division of Agricultural Sciences, University of California, Berkeley, California, USA 94720

The Strawberry Cultivars to Marketing

Ed. N.F. Childers, U.S. Funds $25.00*, includes postage, Horticulture Publications 2906, N.W. 310th Place, Gainesville, Florida,USA 32601

Proceedings, Illinois Strawberry School

Annual publication (back issues available, $2 - 3.00 U.S.*/ copy, University of Illinois, Dixon Springs, Agricultural Center, Simpson, Illinois, USA, 62985

Strawberry Deformities

B.L. Parker and Richard P. Marini, Agricultural Experiment Station, University of Vermont, Bulletin No. 693.

Insect Pests of Strawberries in Ohio

Extension Bulletin No. 667, Agdex 232/624, $1.50 U.S.* funds, Ohio Agricultural Research and Development Center, Wooster, Ohio,USA.

North American Strawberry Growers Association, Annual Research Reports

Membership required. Contact Dr. Richard C. Funt or Mrs. Shirley Funt, P.O. Box 20268, Columbus, Ohio, USA 43220 or phone (614) 459-0733

Small Fruit Crop Management

Gene J. Galletta & David G. Himelrich, Editors, Publication #1-13-814609-8, Prentice-Hall, Inc., Div. of Simon & Schuster, Englewood Cliffs, New Jersey, USA 07632

* Note: Prices quoted are best available information at time of printing.